Special Publication No. 02-03

Biological Escapement Goal for Sockeye Salmon in the Situk River, Yakutat, Alaska

by

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December 2002

Alaska Department of Fish and Game **Division of Sport Fish**

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
ounce	oz
pound	lb
quart	qt
yard	yd

Spell out acre and ton.

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
minute	min
second	s

Spell out year, month, and week.

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

All commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.
All commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.
and	&
at	@
Compass directions:	
east	E
north	N
south	S
west	W
Copyright	©
Corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
et alii (and other people)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.,
id est (that is)	i.e.,
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
number (before a number)	# (e.g., #10)
pounds (after a number)	# (e.g., 10#)
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)

Mathematics, statistics, fisheries

Alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	F, t, χ^2, etc.
confidence interval	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
standard length	SL
total length	TL
variance	Var

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December 2002

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This document should be cited as:
Clark, J. H., S. A. McPherson, and G.F. Woods 2002. Biological escapement goal for sockeye salmon in the Situk River, Yakutat, Alaska. Alaska Department of Fish and Game, Special Publication No. 02-03, Anchorage.

TABLE OF CONTENTS

Page

LIST OF TABLES ii

LIST OF FIGURES ii

LIST OF APPENDICES iii

ABSTRACT 1

INTRODUCTION 1

RUN RECONSTRUCTIONS 3

- Situk River Weir Counts of Sockeye Salmon 3
- Sport Fishery Harvests 3
- Spawning Escapements 6
- Situk Commercial and Subsistence Set Gill Net Fishery 6
- Situk Commercial and Subsistence Set Gill Net Fishery Stock Allocations 9
- Total Inshore Runs of Situk River Origin Sockeye 14
- Situk River Origin Sockeye Salmon Harvested in Other Fisheries and Estimated Total Runs 14

TOTAL RETURNS AND ESTIMATES OF RECRUITS 23

- Age Composition of Sockeye Salmon 23
- Age Specific Total Returns and Estimates of Recruits 25

SPAWNER-RECRUIT ANALYSIS 25

RECOMMENDATIONS 31

ACKNOWLEDGMENTS 32

LITERATURE CITED 33

APPENDIX A 35

LIST OF TABLES

Table **Page**

1. Expansions of sockeye salmon counts past the Situk River weir in years when flood and high water events caused the weir project to be terminated early. 4
2. Counts of sockeye salmon past the Situk River weir site, estimated upstream sport fishery harvest removals, and estimated escapement, 1976-2002. 5
3. Estimated sport harvests of sockeye salmon in the Situk River, 1976-2002. 7
4. Proportions of sockeye salmon sampled and aged as "zero-checks" (age-0. fish) from the Situk escapement, and Situk catch, standard errors, 95% confidence intervals, differences in the proportions, and overlaps in the confidence intervals, 1982-2002. 10
5. Estimates of the proportion of Ahrnklin origin sockeye salmon harvested in the Situk Lagoon commercial/subsistence fishery, 1982-2002. 13
6. Commercial and subsistence harvests of sockeye salmon in the Situk Lagoon fishery and estimates of those harvests into Lost River, Ahrnklin River, and Situk River origin fish. 15
7. Estimated inshore runs of Situk River origin sockeye salmon, 1976-2002. 16
8. Harvest of sockeye salmon in the Yakutat Bay fishery and three alternate estimates of the number of those fish that were of Situk River origin based upon three alternate assumptions. 21
9. Estimated total returns of Situk River origin sockeye salmon under three alternate Yakutat Bay catch allocation assumptions, 1976-2002. 22
10. Percent age composition (in total age) estimates of the annual Situk River sockeye salmon runs, 1976-2002 based upon sampling conducted at the Situk River weir in the years 1982-2002 26
11. Situk River origin sockeye salmon estimated escapements and estimated recruits resulting from those escapements under three alternate assumptions concerning the portion of sockeye salmon harvested in the Yakutat Bay fishery that were of Situk River origin, brood years 1976-1997 27
12. Statistics from stock-recruit relationships calculated for Situk River origin sockeye salmon under three alternate assumptions concerning Situk origin fish harvested in the Yakutat Bay fishery. 29

LIST OF FIGURES

Figure **Page**

1. Map of the Situk River drainage, Situk-Ahrnklin Inlet and upper and lower weir sites. 2
2. Precision of spawning escapement estimates, Situk River sockeye salmon, 1976-2002 (the vertical lines represent 95% confidence intervals). 8
3. Proportions of sockeye salmon aged as "zero-checks" (age-0. fish) in the Situk Lagoon catch samples (upper) and in the Situk escapement (lower). Vertical lines represent 95% confidence intervals 11
4. Precision of inshore run estimates , Situk River sockeye salmon, 1976-2002 (the vertical lines represent 95% confidence intervals). 17
5. Estimated inshore exploitation rate of Situk origin sockeye salmon, 1976-2002. 18
6. Estimated inshore runs of Situk origin sockeye salmon (black bars) and the total commercial and subsistence harvests of sockeye salmon in the mixed stock Yakutat Bay fishery (open bars). 18
7. Age compositions (percent of total age-4 and total age-5) for sockeye salmon sampled from the Situk Lagoon fishery (upper), the Situk River escapement (middle), and for just the age-0. fish sampled from the Situk Lagoon fishery (lower), 1982-2002. 24
8. Stock-recruit relationship for Situk River origin sockeye salmon with the assumption that 50% of the Yakutat Bay harvest of sockeye salmon are fish of Situk River origin. 30
9. Residuals in the stock-recruit relationship for Situk River origin sockeye salmon with the assumption that 50% of the Yakutat Bay harvest of sockeye salmon are fish of Situk River origin. 30

LIST OF APPENDICES

Appendix **Page**

A1. Yakutat Bay sockeye salmon harvest allocations based upon instantaneous fishing effort. The 1987 estimate (in bold) represents direct sampling based estimation of the interception of Situk origin sockeye salmon in the Yakutat Bay fishery. 37

A2. Yakutat Bay sockeye salmon harvest allocations based upon proportions of age-2. and -3. fish. The 1987 estimate (in bold) represents direct sampling based estimation of the interception of Situk origin sockeye salmon in the Yakutat Bay fishery. 38

A3. Yakutat Bay sockeye salmon harvest allocations based upon proportions of total Yakutat Area inshore sockeye salmon runs. The 1987 estimate (in bold) represents direct sampling based estimation of the interception of Situk origin sockeye salmon in the Yakutat Bay fishery. 39

A4. Estimated age specific (in total age) total returns of Situk River sockeye salmon under the assumption that 25% of the harvest in the Yakutat Bay fishery are fish of Situk River origin, 1976-2002. 40

A5. Estimated age specific total returns of Situk River sockeye salmon under the assumption that 50% of the harvest in the Yakutat Bay fishery are fish of Situk River origin, 1976-2002..... 41

A6. Estimated age specific total returns of Situk River sockeye salmon under the assumption that 75% of the harvest in the Yakutat Bay fishery are fish of Situk River origin, 1976-2002..... 42

ABSTRACT

Commercial, sport, and subsistence/personal use catches, escapements, and age compositions of sockeye salmon *Oncorhynchus nerka* returning to the Situk River during the years 1976-2002 were analyzed to develop spawner-recruit relationships. The independent variable in the relationships was based on counts of upstream migrating sockeye salmon made at a weir located in the Situk River minus upstream sport fishery removals. Total adult recruitments of Situk River origin sockeye salmon from the 1976 through 1997 brood years were estimated from inriver catches and escapement and marine harvests offshore, based upon three alternate assumptions concerning the portion of Situk origin sockeye salmon that were annually harvested in the Yakutat Bay fishery. These three data sets represented the dependent variables in the spawner-recruit relationships. The regression based spawner-recruit relationships were used to estimate the escapement level (about 50,000) that, on average, will produce maximum sustained yield of sockeye salmon in Situk River fisheries (about 70,000). Based on this analysis, it is recommended that the Alaska Department of Fish and Game retain 50,000 sockeye salmon as the point estimate of the escapement level that is predicted to produce maximum sustained yield in fisheries, on average. The Alaska Department of Fish and Game adopted a management range of 30,000 to 70,000 sockeye salmon counted past the Situk River weir in 1995. This was the escapement range predicted to produce 90% or more of the estimated maximum sustained yield of sockeye salmon to fisheries. The current analysis reaffirms this as the range of escapements that is most likely to produce 90% of more of estimated maximum sustained yield from the Situk River sockeye salmon stock. We recommend that the current escapement goal range be retained.

Key Words: sockeye salmon, *Oncorhynchus nerka*, Situk River, brood table, spawner-recruit, escapement goal.

INTRODUCTION

Sockeye salmon *Oncorhynchus nerka* returning to the Situk River, near Yakutat, Alaska, support commercial set gill net, sport, and subsistence/personal use fisheries. The commercial set gill net fishery (fishing district 182-70) takes place in the Situk-Ahrnklin Inlet where the Situk, Ahrnklin, and Lost rivers drain into the Gulf of Alaska (Figure 1). Commercial harvests of sockeye salmon in the Situk-Ahrnklin Inlet set gillnet fishery have been directly enumerated since Statehood. Sockeye salmon harvested in this fishery have been sampled for age, sex, and size composition annually since 1982. The sport fishery takes place in freshwater, predominantly in the Situk River below the Forest Highway 10 (Figure 1). Sport fishery harvests of sockeye salmon in the Situk River have been directly monitored since 1977. The subsistence/personal use fishery takes place both in the inlet and in the river itself. The harvest of sockeye salmon in the Situk River subsistence/personal use fishery has been directly monitored since 1985.

Documented spawning locations for sockeye salmon returning to the Situk River system include tributaries and beaches of Situk and Mountain lakes, the Situk River below Situk Lake, the Old Situk River, the West Fork of the Situk River and Redfield Lake (Figure 1). Most of the spawning population of sockeye salmon is believed to return to the portion of the drainage located upstream of the outlet of Situk Lake. In 1971, the escapement of sockeye salmon into the Situk River system was monitored with the aid of a weir located just downstream of Forest Highway 10 (Figure 1). The weir was again operated at this site during the years 1976 through 1987. In 1988 the weir was moved downstream and installed just above the area of tidewater influence. Annual escapements of sockeye salmon have been enumerated at this site from 1988 through the current year. The escapements of sockeye salmon into the Situk River have been sampled for age, sex and size composition annually since 1982.

For several years prior to 1995, the Situk-Ahrnklin Inlet and in-river fisheries were managed by the Alaska Department of Fish and Game to achieve an escapement goal of 45,000 to 55,000 sockeye salmon past the Situk River weir. In 1995, the Alaska Department of Fish and Game adopted 30,000

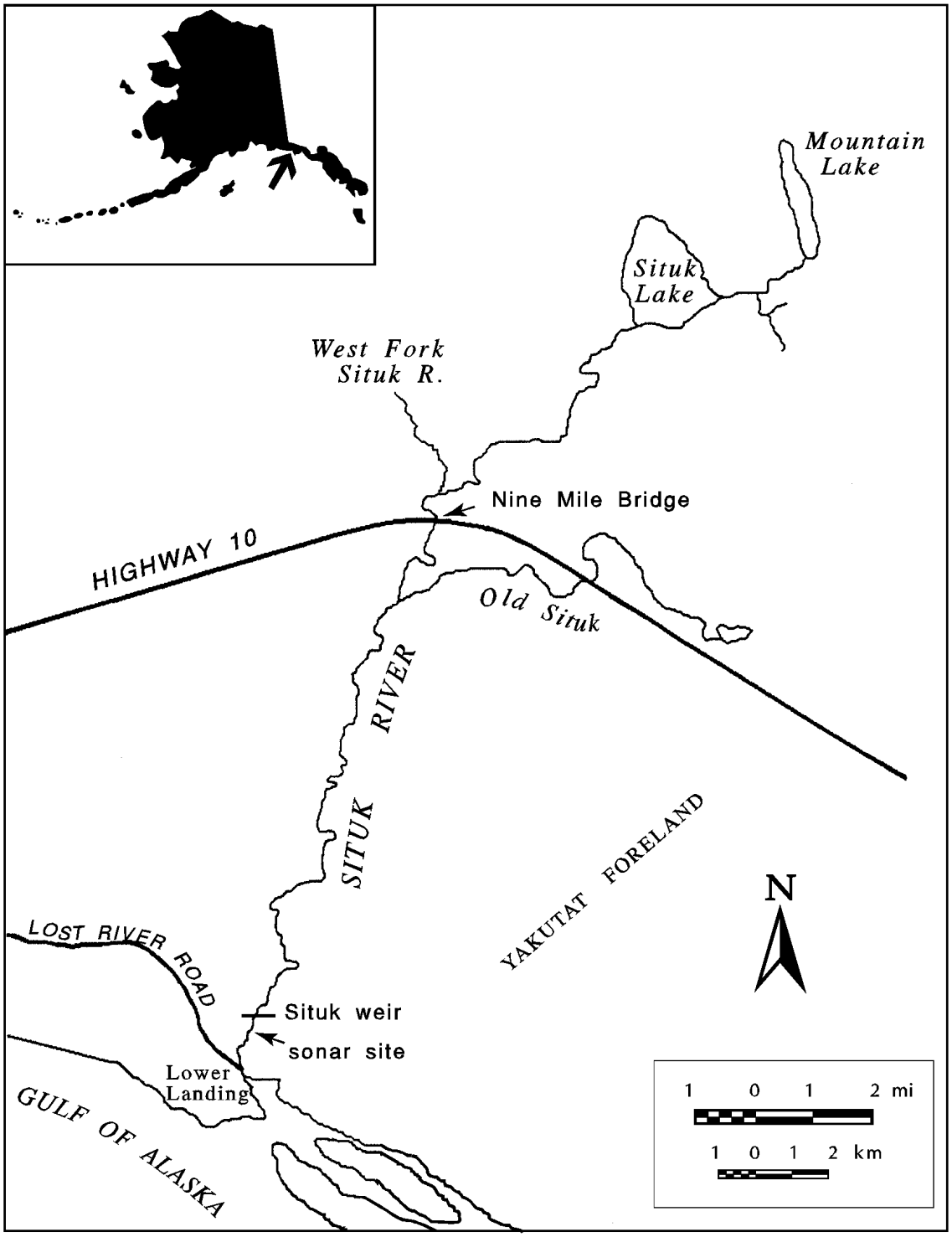

Figure 1.- Map of the Situk River drainage, Situk-Ahrnklin Inlet and upper and lower weir sites.

to 70,000 sockeye salmon past the Situk River weir as a management goal (Clark, McPherson, and Burkholder 1995). The Clark, McPherson, and Burkholder (1995) report recommended that the management goal of 30,000-70,000 sockeye salmon past the Situk River weir be reexamined in five years (2001). The purpose of this report is to reanalyze the Situk River sockeye salmon management goal adopted in 1995 and make recommendations concerning whether it should be retained or replaced.

RUN RECONSTRUCTIONS

SITUK RIVER WEIR COUNTS OF SOCKEYE SALMON

Sockeye salmon were enumerated with the aid of a weir in 1971 and in each year since 1976. The weir was located about 50 meters downstream of Nine Mile Bridge (Forest Highway 10) across the Situk River in 1971 and from 1976-1987. While this site was logistically advantageous, the sockeye salmon had spent several days in the river migrating upstream. In 1988 the weir site was moved downstream so that weir counts provided more timely information for in-season management of the commercial set gill net fishery. Hence, from 1988-present, the weir has been located in the lower Situk River just a mile or so above tidewater and in closer proximity to the commercial fishery, with timing one to two days from the fishery proper.

The counts of sockeye salmon moving upstream past the Situk River weir are considered a census without sampling variance in the years when the weir was successfully held in place throughout the entire run. High water from flood events caused early termination of the weir in the years 1980, 1991, and 1996. Run timing information from other years in the series was used to expand the counts obtained in those three years into total estimated runs past the weir site (Table 1). Total counts of sockeye salmon past the weir site from 1976-2002 ranged from 41,554 fish in 2000 to 216,631 fish in 1977 (Table 2).

SPORT FISHERY HARVESTS

An active sport fishery that harvests sockeye salmon takes place in the Situk River. Road access to the Situk River for sport fishing occurs at two sites. One road provides access to the lower Situk River about one mile below the lower weir site. The Forest Highway 10 assess is at Nine Mile Bridge that crosses the Situk River approximately twelve miles upstream. Sport fishermen fish from the bank after accessing the river and from boats. Sport fishermen launch boats and rafts at Nine Mile Bridge and float downstream and exit the fishery at the lower road accessible site.

Sport fishing is not allowed within a specified distance from a weir site. Hence, from 1976-1987, virtually all sport fishing occurred below the weir site and weir counts of sockeye salmon in those years provides an estimate of the spawning escapement. However, weir counts of sockeye salmon since 1988 have to be adjusted for estimated sport fishery removals above the weir, in order to estimate spawning escapements.

The sport harvest of sockeye salmon in the Situk River is monitored through a statewide postal questionnaire that has been conducted each year since 1977. Sport harvest estimates for1977-2000 are available from published reports, from which we extracted the statistics concerning these harvests. The harvest of sockeye salmon in 1976 was not directly monitored, but we approximated this annual harvest as the average value for the five-year period of 1977-1981. Preliminary statistics from the 2001 survey concerning the harvest of Situk River sockeye salmon were provided to us by Joanne MacClellan (Research and Technical Services, Sport Fish Division, Anchorage). We approximated the 2002 harvest of sockeye salmon from the Situk River as the average value for the five-year period of 1997-2001.

Table 1.- Expansions of sockeye salmon counts past the Situk River weir in years when flood and high water events caused the weir project to be terminated early.

Statistic	1980	1991	1996
Date that weir project terminated	July 29th	July 27	July 22
Sockeye count through that date	79,058	67,737	49,596
Years used to expand count	71, 76-87	88-90,92-95,97-00	88-90,92-95-97-00
Number of years used	12	11	11
Avg. date of weir termination (year)	Aug. 17th	Aug 9th	Aug 9th
Earliest date of weir termination (year)	Aug. 13th (1981)	Aug. 3rd (1995)	Aug. 3rd (1995)
Latest date of weir termination	Aug. 23rd (1982)	Aug. 20 (1988)	Aug. 20 (1988)
Avg. proportion of total on that date	84%	86%	77%
Min. proportion of total on that date	72% (1979)	82% (1993)	71% (1988)
Max. proportion of total on that date	93% (1981)	90% (1992)	84% (1998)
Avg. expansion factor	1.207	1.164	1.297
SE of expansion factor	0.115	0.029	0.030
Expanded count	95,424	78,818	64,313
SE of estimate of expanded count	10,981	2,293	4,500

Table 2.- Counts of sockeye salmon past the Situk River weir site, estimated upstream sport fishery harvest removals, and estimated escapement, 1976-2002.

Year	Weir Location	Weir Count	SE of Weir Count	Estimated Sport Harvest Above Weir[a]	SE of Sport Harvest Above Weir	Estimated Escapement	SE of Estimated Escapement
1976	9-mile	116,989	0	-		116,989	0
1977	9-mile	216,631	0	-		216,631	0
1978	9-mile	146,884	0	-		146,884	0
1979	9-mile	128,879	0	-		128,879	0
1980	9-mile	95,424	10,981	-		95,424	10,981
1981	9-mile	61,774	0	-		61,774	0
1982	9-mile	75,501	0	-		75,501	0
1983	9-mile	63,645	0	-		63,645	0
1984	9-mile	58,188	0	-		58,188	0
1985	9-mile	107,586	0	-		107,586	0
1986	9-mile	71,543	0	-		71,543	0
1987	9-mile	72,720	0	-		72,720	0
1988	Lower R.	46,404	0	244	100	46,160	100
1989	Lower R.	84,383	0	707	289	83,676	289
1990	Lower R.	69,961	0	589	241	69,372	241
1991	Lower R.	78,818	2,293	896	366	77,922	2,322
1992	Lower R.	76,733	0	718	293	76,015	293
1993	Lower R.	62,107	0	2,825	1,154	59,282	1,154
1994	Lower R.	72,474	0	1,490	609	70,984	609
1995	Lower R.	42,463	0	1,552	634	40,911	634
1996	Lower R.	64,313	4,500	1,028	315	63,285	4,511
1997	Lower R.	42,051	0	3,869	1,016	38,182	1,016
1998	Lower R.	50,546	0	4,468	1,063	46,078	1,063
1999	Lower R.	61,544	0	2,912	881	58,632	881
2000	Lower R.	41,554	0	5,232	962	36,322	962
2001	Lower R.	60,334	0	2,642	793	57,692	793
2002	Lower R.	68,743	0	3,360	1,008	65,383	1,008
Min.	1976-1997	42,051		-		38,182	
Max.	1976-1997	216,631		2,825		216,631	
Contrast						5.67	

[a] Sport fishery harvest estimates taken from Table 3.

In the years 1996-2001, participants in the survey have been directly queried concerning their harvests above and below the weir site, whereas in earlier years, the participants were only queried concerning their harvests from the entire Situk River. On average, in the years 1996-2001, the sport harvest above the lower weir site was 42% of the total harvest of sockeye salmon. We applied this statistic (42%) to the total Situk River sport harvests of sockeye salmon in the years 1988-1995 and 2002 to estimate the harvests of sockeye salmon above the weir for those years.

The sport fishery harvest estimates are not a census, but are instead estimates with sampling variance. Standard errors for Situk River sockeye salmon harvest estimates were available for the years 1996-2001. Estimates of the precision of the harvest estimates for earlier years are not available. The coefficients of variation for the above weir harvest estimates ranged from 18% to 31% for the years 1996-2001. We assumed coefficients of variation of 30% for the estimates in the other years in the data set.

Estimated sport fishery harvests of Situk River sockeye salmon since 1976 ranged from 61 fish in 1985 to 9,853 fish in 2000 (Table 3). The estimates of the above weir removals of sockeye salmon by the sport fishery since 1988 ranged from 244 fish in 1988 to 5,232 fish in 2000 (Tables 2 and 3).

SPAWNING ESCAPEMENTS

Estimates of the sport fishery harvests of sockeye salmon above the weir were subtracted from weir counts of sockeye salmon for the years 1988-2002 to estimate spawning escapement. Weir based counts alone were used for sockeye salmon spawning escapement estimates for the years 1976-1987. Estimated spawning escapements of sockeye salmon in the Situk River from 1976-1997 ranged from 38,182 fish in 1997 to 216,631 fish in 1977 providing a contrast of 5.67-fold for current stock-recruit analysis (Table 2). Estimated coefficients of variation of spawning escapement estimates ranged from a high of 12% for 1980 to 0% for most of the years prior to 1990. Most of the estimates for years since 1990 had coefficients of variation of a few percent. Confidence intervals (95%) for estimated spawning escapements for the years 1976-2002 is provided in Figure 2. Thus, although contrast of spawning escapements observed since 1976 is not great, the precision of most of these estimates is good and it is readily apparent that the abundance of many of these escapements are statistically different with the higher escapements occurring in the early years of the series. This is not surprising as the Situk fisheries for the last couple of decades have been actively managed to achieve a specified annual level of escapement (i.e. 30,000-70,000 since 1995).

SITUK COMMERCIAL AND SUBSISTENCE SET GILL NET FISHERY

A terminal commercial fishery for sockeye salmon takes place in the Situk-Ahrnklin Inlet. Commercial fishing gear is limited to set-gillnet gear. Commercial harvests of sockeye salmon in the Situk fishery from 1976 to 2002 were summarized from fish ticket information. Fish tickets are sales receipts filled out when commercial fishermen sell fish to processors, by regulation. This harvest information is considered a complete census without sampling variance and without bias.

A terminal subsistence fishery for sockeye salmon also takes place in the Situk-Ahrnklin Inlet. For the most part, subsistence fishermen are the same individuals that participate in the commercial fishery. They use the same gear to subsistence fish when the commercial fishery is closed or they retain some fish caught during commercial fishing periods for personal use. Subsistence permits are annually issued by ADF&G to individuals that wish to participate in the subsistence fishery. At the end of the year, these individuals are required to return the permit, including a written record of the number of fish harvested. Existing subsistence catch records from these returned permits were summarized to estimate annual subsistence harvests of sockeye salmon in the Situk fishery.

Permit-based direct estimates of the Situk-Ahrnklin Inlet subsistence harvests of sockeye salmon are available for the years 1985-2001. We estimated the subsistence harvests for the years 1976-1984 as 1,300 sockeye salmon per year, the average value for the five-year period of 1985-1989. Similarly,

Table 3.- Estimated sport harvests of sockeye salmon in the Situk River, 1976-2002.

Year	Estimated Sport Harvest Below Weir	Estimated Sport Harvest Above Weir	SE of Sport Harvest Above Weir	Estimated Total Sport Harvest	SE of Estimated Total Sport Harvest
1976		0		466[a]	140[e]
1977		0		497	149[e]
1978		0		578	173[e]
1979		0		145	44[e]
1980		0		818	245[e]
1981		0		292	88[e]
1982		0		419	126[e]
1983		0		274	82[e]
1984		0		346	104[e]
1985		0		61	18[e]
1986		0		306	92[e]
1987		0		1,105	332[e]
1988	338	244[d]	100[e]	582	175[e]
1989	976	707[d]	289[e]	1,683	505[e]
1990	814	589[d]	241[e]	1,403	421[e]
1991	1,238	896[d]	366[e]	2,134	640[e]
1992	991	718[d]	293[e]	1,709	513[e]
1993	3,902	2,825[d]	1,154[e]	6,727	2,018[e]
1994	2,058	1,490[d]	609[e]	3,548	1,064[e]
1995	2,144	1,552[d]	634[e]	3,696	1,109[e]
1996	4,447	1,028	315	5,475	922
1997	4,252	3,869	1,016	8,121	1,509
1998	4,980	4,468	1,063	9,448	1,430
1999	4,287	2,912	881	7,199	1,275
2000	4,621	5,232	962	9,853	1,358
2001	3,035[b]	2,642[b]	793[b]	5,677[b]	1,703[b]
2002	4,640	3,360[d]	1,008[e]	8,000[c]	2,400[e]

[a] The sport harvest was not monitored in 1976. The proxy value listed represents the average for the years 1977-1981.

[b] Preliminary statistics provided by Joanne MacClellan (RTS, Sport Fish Division, Anchorage).

[c] Direct fishery monitoring data not yet available. The proxy value listed represents the approximate average for the years 1997-2001.

[d] Estimate is based on the assumption that the harvest above the weir represents 42% of the total harvest.

[e] Standard error is estimated as 30% of the estimate itself.

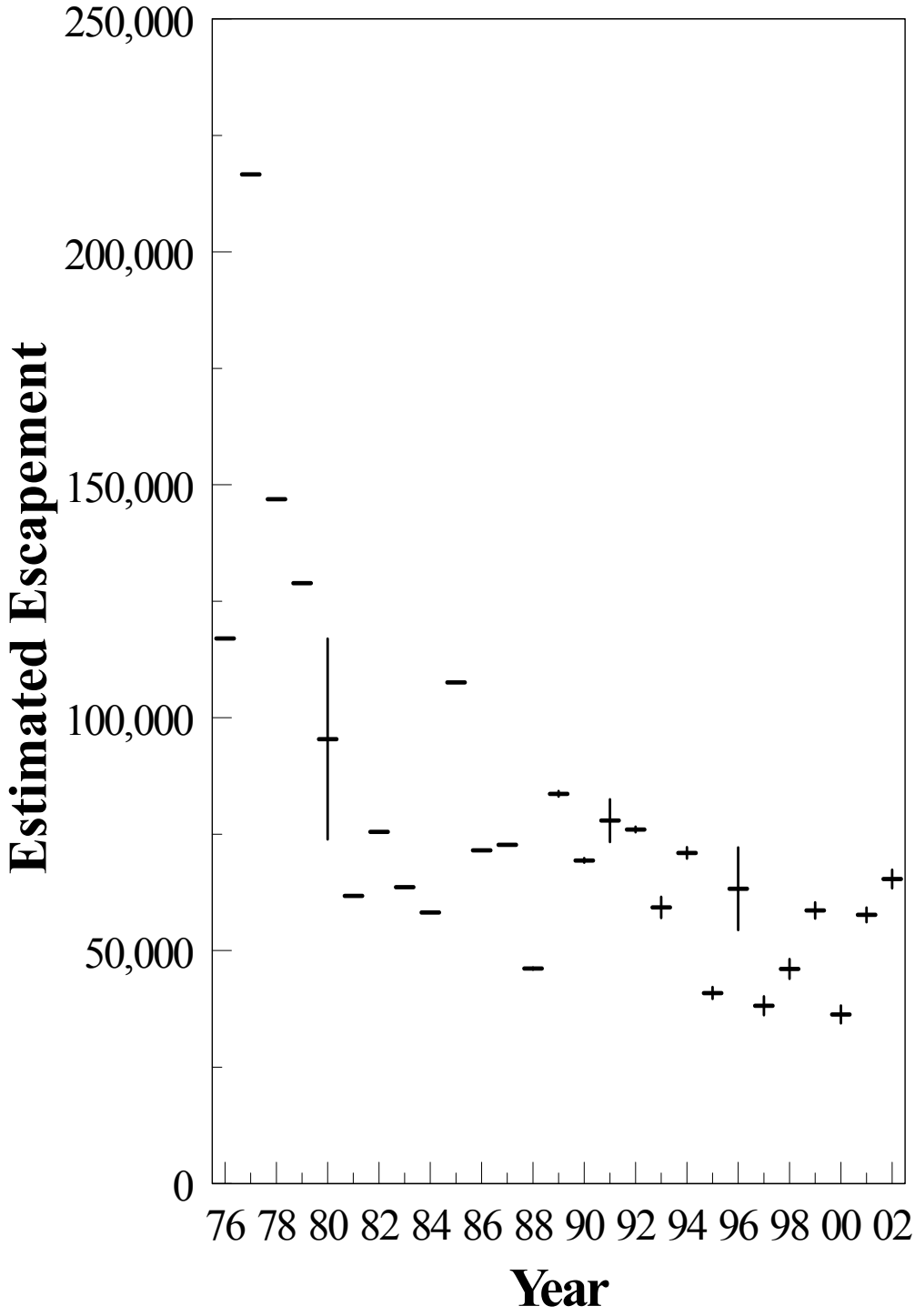

Figure 2.- Precision of spawning escapement estimates, Situk River sockeye salmon, 1976-2002 (the vertical lines represent 95% confidence intervals).

the 2002 subsistence harvest is not yet available, we estimated the 2002 subsistence harvest as 3,300 sockeye salmon, the approximate average for the five-year period of 1997-2001.

Subsistence harvest estimates are judged to be reliable as far as information turned in on subsistence permits. What is unaccounted for, to some extent, is the number of sockeye salmon retained for personal use by commercial fishermen from their commercial catch. The ADF&G has always requested that those fish retained for personal use be reported on fish tickets, but there is no enforceable regulation to require this action and those fish may go unreported. There is not a scientific method to estimate these numbers. However, professional judgement of the local fishery manager is that it is doubtful in any given year that more than 100 or so fish were kept for personal use. As a result, a moderate negative bias is likely associated with these numbers. Further, an unknown level of sampling variance is associated with these annual estimates of harvest. However, subsistence harvests are so minor in comparison to commercial harvests as to be all but inconsequential in most years, averaging about 1% of the combined harvest estimates. Therefore, we consider the combined commercial/subsistence harvest estimates to be a census with little to no sampling variance and little to no bias that affects analysis in this report.

SITUK COMMERCIAL AND SUBSISTENCE SET GILL NET FISHERY STOCK ALLOCATIONS

While we believe there is little uncertainty regarding the number of sockeye salmon harvested in the Situk commercial/subsistence fishery, there is uncertainty regarding how many of those fish are of Situk River origin. Both the Situk River and the Ahrnklin River are tributary to the Inlet and both rivers support substantial sockeye salmon production. Additionally, since 1999, the Lost River also drains into the Inlet. The Lost River supports a small population of sockeye salmon. As a consequence, the catches of sockeye salmon in the Situk commercial/subsistence fishery since 1999 represent a mix of fish from three discrete spawning populations. The harvests of Lost River sockeye salmon can be effectively dealt with in a rather simple manner due to the small run sizes and potential limited affect on the Situk origin run reconstructions. The allocation of Situk-Ahrnklin Inlet catches into Situk origin versus Ahrnklin origin sockeye salmon is a more difficult task.

The Situk River sockeye salmon spawning stock has been sampled for age composition each year since 1982 and the Situk Lagoon commercial harvest of sockeye salmon has been similarly sampled. While large numbers of “zero-check” (age-0. sub-yearling type) sockeye salmon have been found in the Situk-Ahrnklin Inlet harvests, few such fish have been found in the Situk River spawning escapements. Although the Ahrnklin River sockeye salmon spawning population has never been sampled for age composition, the sampling of an Ahrnklin section only commercial fishery in 1987 found that 71% of the sampled harvest were age-0. fish. As a result, we believe the Ahrnklin River sockeye salmon population is comprised of mostly age-0. sockeye salmon, while sockeye salmon that return to the Situk River seldom utilize this age/life history feature. Further, we believe that the annual differences in age-0. sockeye salmon age compositions directly monitored in the Situk escapement and catch samples through the years is due to the presence and relative abundance of Ahrnklin origin sockeye salmon in the mixed stock Situk Lagoon fishery. In all of the 21 years that sampling has occurred, the proportions of age-0. sockeye salmon in the Situk catch are higher than in the Situk escapements, precision of these estimates is good, and there is no overlap in 95% confidence intervals (Table 4 and Figure 3).

Although this measured statistic (the difference in proportions of age-o. fish sampled) appears to provide a relative measure of the magnitude of Ahrnklin origin sockeye salmon in the Inlet fishery, this variable needed to be converted into a harvest allocation scheme. There are two other pieces of information available to utilize for this purpose.

Table 4.-Proportions of sockeye salmon sampled and aged as "zero-checks" (age-0. fish) from the Situk escapement, and Situk catch, standard errors, 95% confidence intervals, differences in the proportions, and overlaps in the confidence intervals, 1982-2002.

Year	Catch Proportion	SE of Catch Proportion	95% C. I. Lower	95% C. I. Upper	Escapement Proportion	SE of Escapement Proportion	95% C. I. Lower	95% C. I. Upper	Difference In Proportion	Overlap in C. I.'s
1982	0.084	0.008	0.069	0.099	0.007	0.003	0.002	0.012	0.076	No
1983	0.187	0.010	0.167	0.206	0.020	0.004	0.013	0.027	0.166	No
1984	0.183	0.014	0.156	0.210	0.039	0.005	0.028	0.049	0.144	No
1985	0.158	0.009	0.142	0.175	0.004	0.002	0.000	0.008	0.154	No
1986	0.216	0.013	0.191	0.242	0.015	0.004	0.007	0.022	0.202	No
1987	0.250	0.009	0.232	0.269	0.007	0.003	0.002	0.013	0.243	No
1988	0.164	0.010	0.145	0.183	0.022	0.005	0.012	0.032	0.142	No
1989	0.260	0.013	0.235	0.286	0.035	0.006	0.022	0.047	0.225	No
1990	0.296	0.011	0.275	0.317	0.133	0.009	0.116	0.151	0.163	No
1991	0.137	0.008	0.122	0.152	0.018	0.004	0.009	0.026	0.119	No
1992	0.180	0.009	0.162	0.198	0.003	0.002	0.000	0.007	0.176	No
1993	0.331	0.012	0.307	0.354	0.103	0.008	0.088	0.119	0.227	No
1994	0.219	0.011	0.198	0.239	0.104	0.009	0.088	0.121	0.114	No
1995	0.181	0.016	0.149	0.213	0.034	0.008	0.018	0.050	0.147	No
1996	0.121	0.014	0.094	0.149	0.034	0.008	0.018	0.050	0.087	No
1997	0.243	0.018	0.207	0.278	0.140	0.016	0.109	0.171	0.103	No
1998	0.233	0.018	0.198	0.268	0.108	0.013	0.082	0.134	0.125	No
1999	0.193	0.017	0.160	0.226	0.079	0.012	0.055	0.103	0.114	No
2000	0.142	0.015	0.112	0.171	0.016	0.006	0.005	0.027	0.126	No
2001	0.164	0.016	0.132	0.195	0.031	0.008	0.015	0.047	0.133	No
2002	0.074	0.010	0.055	0.094	0.032	0.008	0.017	0.046	0.043	No

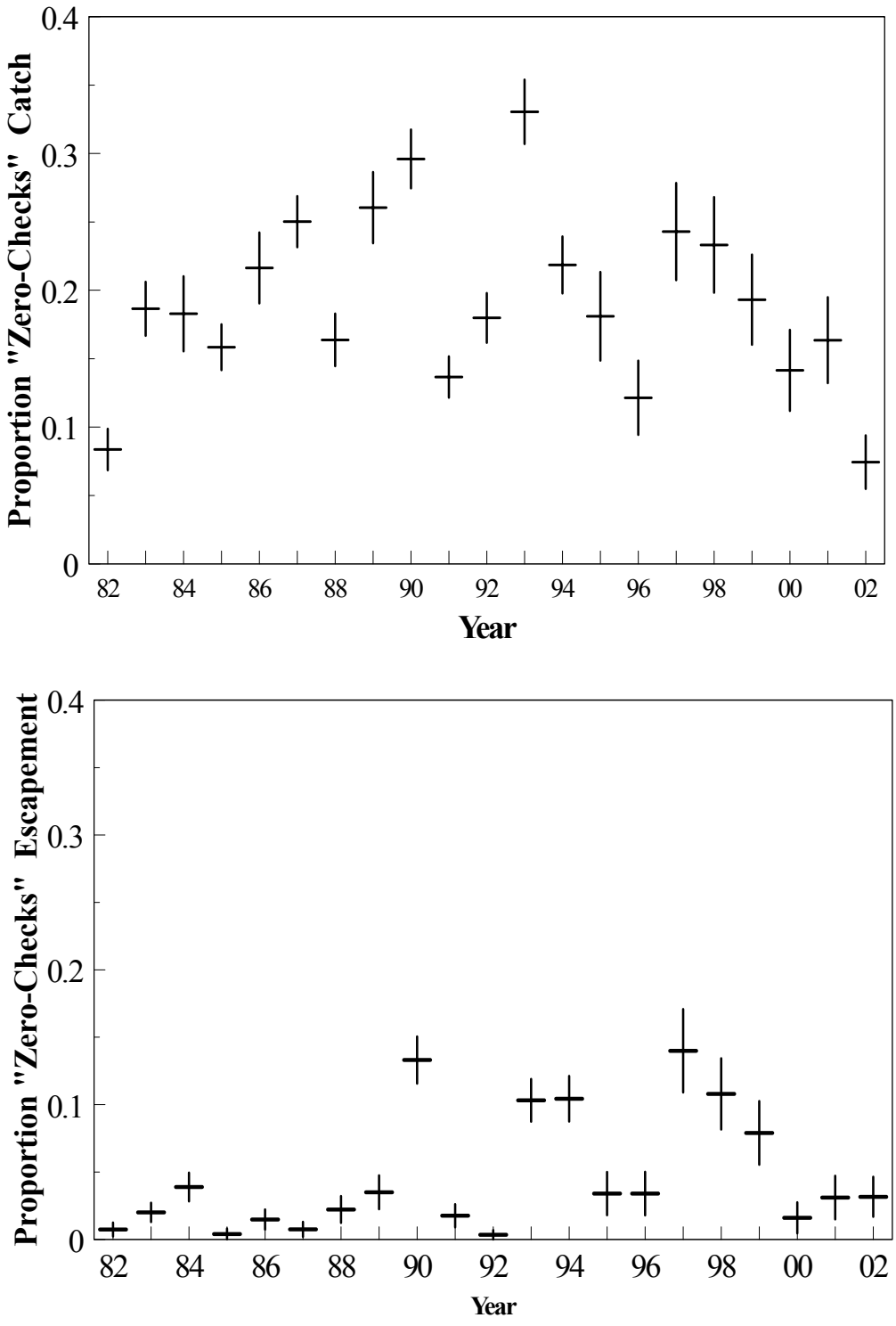

Figure 3.- Proportions of sockeye salmon aged as "zero-checks" (age-0. fish) in the Situk Lagoon catch samples (upper) and in the Situk escapement (lower). Vertical lines represent 95% confidence intervals

First, a coded wire tag recovery study was implemented in 1987. In 1984, sockeye salmon smolt were captured in the Situk River and implanted with coded wire tags. In 1987, sockeye salmon harvested by commercial fishermen in the Inlet were sampled to recover coded wire tags. An analysis of these data revealed that only 0.731 (S. E. = 0.213) of the sockeye salmon harvested were of Situk origin (McPherson and Clark 1995). Presumably, the majority of the non-Situk origin fish were Ahrnklin origin sockeye salmon (26.9%).

Second, the U.S. Forest Service implemented a mark-recapture study of the Ahrnklin River sockeye salmon spawning population in 2001 (Schaberg 2002). In the first event, 1,127 fish were marked while in the second event, 1,483 fish were recaptured of which 70 were fish marked during the first event. The 2001 spawning abundance of Ahrnklin River sockeye salmon was estimated to have been 23,556 fish (S. E. = 2,709). The Situk weir count in 2001 was 60,334 sockeye salmon. The Lost River sockeye salmon escapement is estimated to have totaled 2,215 (peak count x 1.5) in 2001. Thus the Ahrnklin River escapement represented 27.4% of the total escapement for the three stocks in 2001 (23,556/(23,556 + 60,334 + 2,215). If these three stocks were exploited at a similar rate in the Situk-Ahrnklin Inlet fishery in 2001, the portion of the total that were of Ahrnklin origin was 27.4% (S. E. = 0.85%).

These two pieces of information provide two annual points with which to "anchor" the age-0. differences. In other words a direct catch allocation based upon tagging in 1987 revealed that the non-Situk origin catch (Ahrnklin stock) represented 26.9% of the total and the age-0. difference in 1987 was age 24.3% (Table 4). The cumulative escapement data available in 2001 indicate that the Ahrnklin origin stock represented 27.4% of the total in 2001 and the age-0.difference in 2001 was age 13.3% (Table 4). These two sets of data were utilized as follows:

Based upon the 1987 coded wire tag data:

$$P_i = (0.269(D_i))/D_{87} \qquad (1)$$

where: P_i is the proportion of Ahrnklin origin sockeye in Situk Lagoon catch in year *i*,
0.269 is the estimate of non-Situk origin fish in 1987,
D_i is the difference in age-0. sockeye proportions in year *i*, and
D_{87} is the difference in age-0. sockeye proportions in 1987 or 0.243.

Based upon the 2001 total escapement approach:

$$P_i = (0.274(D_i))/D_{01} \qquad (2)$$

where: P_i is the proportion of Ahrnklin origin sockeye in Situk Lagoon catch in year *i*,
0.274 is the estimate of Ahrnklin origin fish in 2001,
D_i is the difference in age-0. sockeye proportions in year *i*, and
D_{01} is the difference in age-0. sockeye proportions in 2001 or 0.133.

Once both approaches were used to estimate the proportion of Ahrnklin origin sockeye salmon in the annual Situk-Ahrnklin Inlet commercial/subsistence fisheries, the two annual estimates were averaged (Table 5). Except for 1987 and 2001 when direct observations were available, the average values were used to represent the best available information concerning the proportion of Ahrnklin fish in these catches for the years 1982-1986, 1988-2000, and 2002. Age sampling information was not available for the years 1976-1981. The proportion of Ahrnklin origin sockeye salmon in the Inlet fishery in the

Table 5.- Estimates of the proportion of Ahrnklin origin sockeye salmon harvested in the Situk Lagoon commercial/subsistence fishery, 1982-2002.

Year	Age-0. Difference	Ahrnklin Proportion Based upon 2001 Data	Ahrnklin Proportion Based upon 2001 Data	Ahrnklin Proportion Based upon Sampling	Average Estimate	SE of Estimate	CV of Estimate
1982	7.6	0.16	0.08		12.1%	7.3%	60%
1983	16.6	0.34	0.18		26.4%	16.0%	60%
1984	14.4	0.30	0.16		22.9%	13.8%	60%
1985	15.4	0.32	0.17		24.5%	14.8%	60%
1986	20.2	0.42	0.22		32.0%	19.3%	60%
1987	24.3	0.50		26.9%		21.3%	79%
1988	14.2	0.29	0.16		22.5%	13.6%	60%
1989	22.5	0.47	0.25		35.8%	21.6%	60%
1990	16.3	0.34	0.18		25.9%	15.6%	60%
1991	11.9	0.25	0.13		18.9%	11.4%	60%
1992	17.6	0.36	0.20		28.0%	16.9%	60%
1993	22.7	0.47	0.25		36.1%	21.8%	60%
1994	11.4	0.24	0.13		18.1%	10.9%	60%
1995	14.7	0.30	0.16		23.3%	14.1%	60%
1996	8.7	0.18	0.10		13.9%	8.4%	60%
1997	10.3	0.21	0.11		16.3%	9.9%	60%
1998	12.5	0.26	0.14		19.9%	12.0%	60%
1999	11.4	0.24	0.13		18.1%	10.9%	60%
2000	12.6	0.26	0.14		19.9%	12.0%	60%
2001	13.3		0.15	27.4%		0.8%	3%
2002	4.3	0.09	0.05		6.8%	4.1%	60%
Avg.	14.4	0.30	0.16		22.7%	13.2%	59%
Min.	4.3				6.8%		3%
Max.	24.3				36.1%		79%

years 1976-1981 was approximated as 0.227, the average value obtained as described above for the years 1982-2002.

Estimation of the proportion of Ahrnklin origin sockeye salmon in the Inlet fishery in this manner provided believable estimates that ranged from 6.8% to 36.1%, however, these estimates are not precise. The 21 annual estimates had coefficients of variation ranging from about 3% to 79% (Table 5). The imprecision associated with many of these estimates mirrors the lack of direct sampling based observations and adds a significant source of uncertainty to our later estimates of total inshore returns of Situk origin sockeye salmon.

As described above, in 1999 the Lost River shifted channels and instead of emptying into its own lagoon system, it now empties into the Situk-Ahrnklin Inlet. The Lost River supports a sockeye salmon spawning population that is much less in magnitude than either the Situk stock or the Ahrnklin stock. Average commercial/subsistence harvests during the five-year period of 1994-1998 was about 1,500 fish. Harvest of sockeye salmon in the Situk fishery for the same period was about 70,000 fish or about 50-fold the Lost River fishery average. Given the level of uncertainty already associated with the estimates of Ahrnklin origin sockeye salmon in the Situk fishery and the fact that no direct sampling based information is available concerning Lost River origin catches in the Situk fishery, we have simply assumed that a harvest of about 1,500 Lost River origin sockeye salmon has occurred in the Situk fishery each year since 1999.

The information described above was used to construct annual estimates of the number of Situk origin sockeye salmon harvested in the Inlet commercial/subsistence fishery for the years 1976-2002 (Table 6). Estimated terminal commercial/subsistence harvests of Situk River origin sockeye salmon in the Inlet ranged from 5,936 fish in 1986 to 99,781 fish in 1991 during the years 1976-2002. The coefficients of variation for these 27 annual estimated harvests of Situk River origin sockeye salmon ranged from 1% to 34%, and averaged 18% (Table 6).

TOTAL INSHORE RUNS OF SITUK RIVER ORIGIN SOCKEYE

The annual inshore runs of Situk River origin sockeye salmon were estimated by adding the annual estimated escapements to the estimated annual sport and commercial/subsistence harvests. Estimated annual inshore runs ranged from 65,246 fish in 1984 to 283,142 fish in 1977 (Table 7). Coefficients of variation ranged from 2% to 18% for the 27 annual estimates, averaging 7% (Table 7). Confidence intervals (95%) for estimates of the total inshore runs of Situk origin sockeye salmon are provided in Figure 4. Estimated inshore exploitation rates of the annual runs of Situk origin sockeye salmon from 1976-2002 ranged from 8% in 1986 to 60% in 1995 and 1996, averaging 39% over the 27 year period (Figure 5).

SITUK RIVER ORIGIN SOCKEYE SALMON HARVESTED IN OTHER FISHERIES AND ESTIMATED TOTAL RUNS

Situk origin sockeye salmon are harvested in fisheries other than the terminal Situk-Ahrnklin Inlet commercial/subsistence fishery and the in-river Situk River sport fishery. The coded wire tagging of emigrating smolt from the Situk River in 1984 documented the harvest of this stock of sockeye salmon in the mixed stock Yakutat Bay fishery. McPherson and Clark (1995) documented that 50.1% of the Yakutat Bay harvest of sockeye salmon in 1987 were fish of the Situk River origin. Although the total harvest of sockeye salmon in the Yakutat Bay fishery is small in most years in comparison to the estimated inshore runs of Situk origin sockeye salmon (Figure 6), the inshore runs, unless adjusted upward, provide negatively biased estimates of total runs. Unfortunately, the only direct sampling based estimate is the 1987 estimate discussed above. Various alternate Yakutat Bay catch allocation schemes were attempted as part of this analysis.

Table 6.- Commercial and subsistence harvests of sockeye salmon in the Situk Lagoon fishery and estimates of those harvests into Lost River, Ahrnklin River, and Situk River origin fish.

Year	Commercial Harvest	Subsistence Harvest	Total Harvest	Lost River Stock	Catch of Situk & Ahrnklin	Percent Ahrnklin Origin	Number Ahrnklin Origin	Number Situk Origin	SE of Situk Origin	CV Situk Origin
1976	60,699	1,300	61,999	0	61,999	22.7%	14,045	47,954	8,169	17%
1977	84,049	1,300	85,349	0	85,349	22.7%	19,335	66,014	11,245	17%
1978	31,363	1,300	32,663	0	32,663	22.7%	7,399	25,264	4,303	17%
1979	46,374	1,300	47,674	0	47,674	22.7%	10,800	36,874	6,281	17%
1980	32,473	1,300	33,773	0	33,773	22.7%	7,651	26,122	4,450	17%
1981	29,103	1,300	30,403	0	30,403	22.7%	6,887	23,516	4,006	17%
1982	29,796	1,300	31,096	0	31,096	12.1%	3,767	27,329	2,275	8%
1983	17,816	1,300	19,116	0	19,116	26.4%	5,052	14,064	3,052	22%
1984	7,401	1,300	8,701	0	8,701	22.9%	1,989	6,712	1,201	18%
1985	18,620	597	19,217	0	19,217	24.5%	4,711	14,506	2,846	20%
1986	7,617	1,113	8,730	0	8,730	32.0%	2,794	5,936	1,688	28%
1987	63,595	1,179	64,774	0	64,774	26.9%	17,424	47,350	13,770	29%
1988	52,128	1,363	53,491	0	53,491	22.5%	12,019	41,472	7,261	18%
1989	99,940	2,477	102,417	0	102,417	35.8%	36,660	65,757	22,146	34%
1990	90,737	2,346	93,083	0	93,083	25.9%	24,075	69,008	14,543	21%
1991	120,123	2,918	123,041	0	123,041	18.9%	23,260	99,781	14,051	14%
1992	105,473	4,472	109,945	0	109,945	28.0%	30,793	79,152	18,601	24%
1993	104,439	3,990	108,429	0	108,429	36.1%	39,119	69,310	23,631	34%
1994	86,007	3,418	89,425	0	89,425	18.1%	16,207	73,218	9,790	13%
1995	73,732	2,547	76,279	0	76,279	23.3%	17,798	58,481	10,751	18%
1996	101,161	3,312	104,473	0	104,473	13.9%	14,499	89,974	8,759	10%
1997	40,893	2,843	43,736	0	43,736	16.3%	7,145	36,591	4,316	12%
1998	37,884	3,505	41,389	0	41,389	19.9%	8,227	33,162	4,970	15%
1999	61,500	3,392	64,892	1,500	63,392	18.1%	11,486	51,906	6,938	13%
2000	34,551	3,443	37,994	1,500	36,494	19.9%	7,272	29,222	4,393	15%
2001	62,192	3,481	65,673	1,500	64,173	27.4%	17,583	46,590	545	1%
2002	71,007	3,300	74,307	1,500	72,807	6.8%	4,946	67,861	2,988	4%

[a] **The subsistence catch was directly monitored from 1985-present. The five-year average of about 1,300 from the years 1985-1989 is used for the early years in the series, specifically for the years 1976-1984. The 2002 estimate is not yet available; the five-year average of about 3,300 from 1997-2001 is used for 2002.**

Table 7.-Estimated inshore runs of Situk River origin sockeye salmon, 1976-2002.

Year	Estimated Spawning Escapement	Estimated Sport Harvest	Estimated Commercial & Subsistence Harvest	Estimated Total Inshore Runs	SE Inshore Runs	CV Inshore Runs	Estimated Inshore Exploitation
1976	116,989	466	47,954	165,409	8,170	5%	29%
1977	216,631	497	66,014	283,142	11,246	4%	23%
1978	146,884	578	25,264	172,726	4,307	2%	15%
1979	128,879	145	36,874	165,898	6,281	4%	22%
1980	95,424	818	26,122	122,364	11,851	10%	22%
1981	61,774	292	23,516	85,582	4,007	5%	28%
1982	75,501	419	27,329	103,249	2,279	2%	27%
1983	63,645	274	14,064	77,983	3,053	4%	18%
1984	58,188	346	6,712	65,246	1,206	2%	11%
1985	107,586	61	14,506	122,153	2,846	2%	12%
1986	71,543	306	5,936	77,785	1,691	2%	8%
1987	72,720	1,105	47,350	121,175	13,774	11%	40%
1988	46,160	582	41,472	88,213	7,263	8%	48%
1989	83,676	1,683	65,757	151,116	22,153	15%	45%
1990	69,372	1,403	69,008	139,782	14,551	10%	50%
1991	77,922	2,134	99,781	179,837	14,256	8%	57%
1992	76,015	1,709	79,152	156,876	18,611	12%	52%
1993	59,282	6,727	69,310	135,318	23,745	18%	56%
1994	70,984	3,548	73,218	147,750	9,867	7%	52%
1995	40,911	3,696	58,481	103,088	10,827	11%	60%
1996	63,285	5,475	89,974	158,734	9,895	6%	60%
1997	38,182	8,121	36,591	82,894	4,684	6%	54%
1998	46,078	9,448	33,162	88,688	5,279	6%	48%
1999	58,632	7,199	51,906	117,737	7,109	6%	50%
2000	36,322	9,853	29,222	75,397	4,697	6%	52%
2001	57,692	5,677	46,590	109,959	1,956	2%	48%
2002	65,383	8,000	67,861	141,244	3,963	3%	54%
Avg.	77,987	2,984	46,412	127,383		7%	39%
Min.	36,322	61	5,936	65,246		2%	8%
Max.	216,631	9,853	99,781	283,142		18%	60%

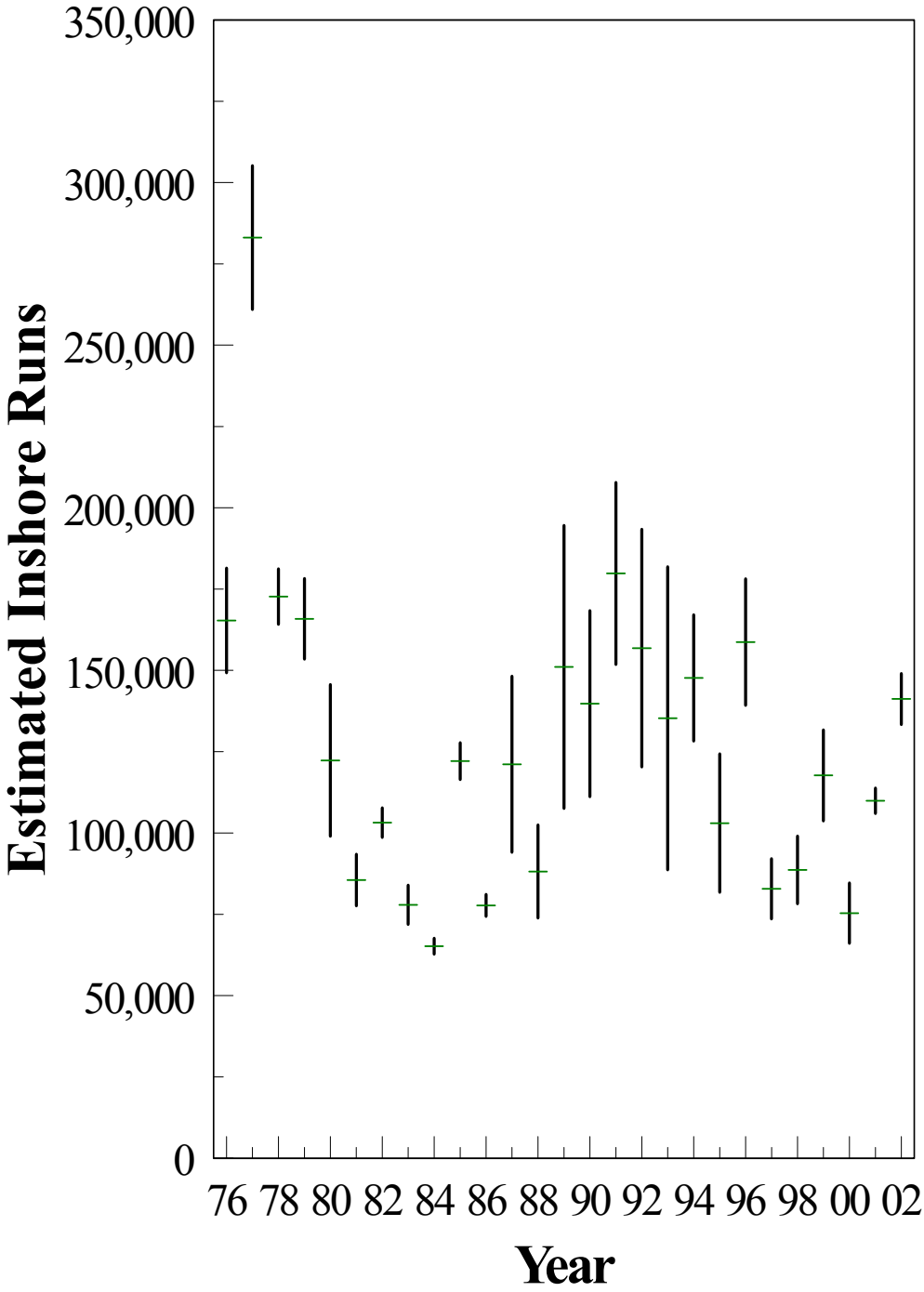

Figure 4.-Precision of inshore run estimates , Situk River sockeye salmon, 1976-2002 (the vertical lines represent 95% confidence intervals).

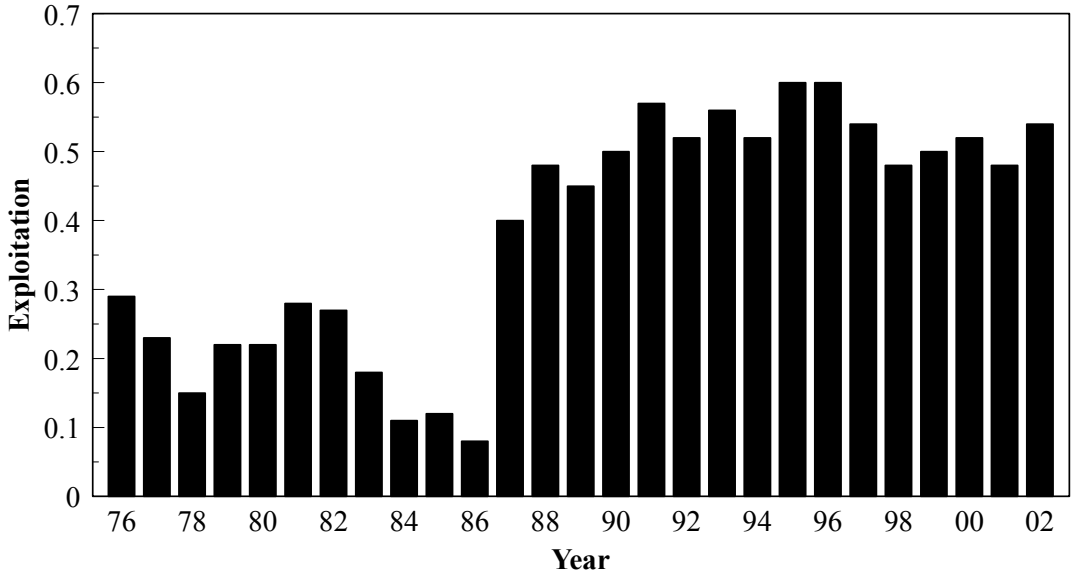

Figure 5.-Estimated inshore exploitation rate of Situk origin sockeye salmon, 1976-2002.

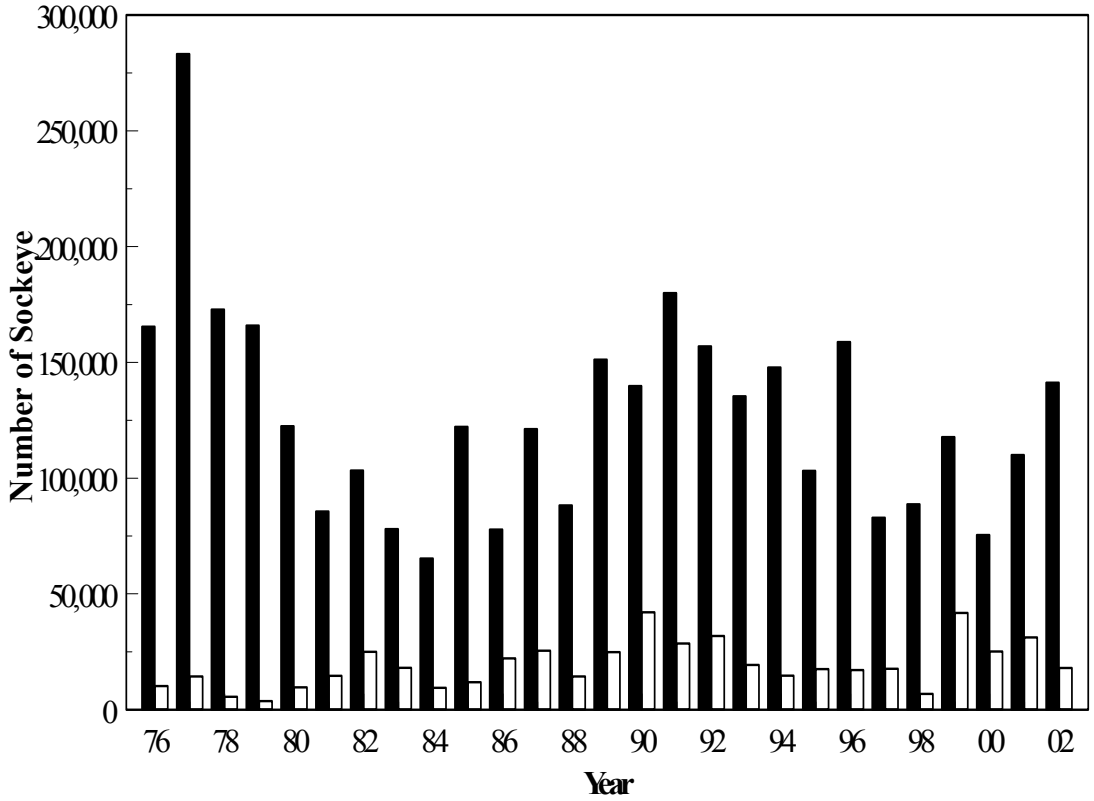

Figure 6.-Estimated inshore runs of Situk origin sockeye salmon (black bars) and the total commercial and subsistence harvests of sockeye salmon in the mixed stock Yakutat Bay fishery (open bars).

The first approach was based upon an assumption concerning instantaneous fishing rates. The fishing effort in the Yakutat Bay fishery in 1987 was 353 boat days. In 1987, the commercial harvest of sockeye salmon in the Yakutat Bay fishery was 25,287 fish and the subsistence catch was estimated to have been 200 sockeye salmon for a total harvest of 25,487 fish. The Situk origin catch in the Yakutat Bay fishery was estimated to have been 50.1% or a total catch of Situk origin sockeye salmon of 12,769 fish. The inshore run of Situk origin sockeye salmon in 1987 was 121,175 fish. Thus the total Situk origin run in 1987 is estimated to have been 133,944 sockeye salmon. Exploitation by the Yakutat Bay fishery is estimated to have been 9.53% for the 353 boat days of fishing effort expended. The exploitation rate per boat day was estimated to have been 0.00027%. This approach to the harvest of Situk origin sockeye salmon in the Yakutat Bay fishery assumed similar instantaneous fishing rates across years. Hence, the constant of 0.00027% was applied to estimates of the annual fishing effort to estimate Situk origin sockeye salmon harvests in the Yakutat Bay fishery. Results of the approach demonstrated that instantaneous fishing rates across the years were not similar. The 27 annual estimates of the percent of Situk origin sockeye salmon in the Yakutat Bay fishery ranged from 37% to 170%, averaging 98%. This implies that Situk origin sockeye salmon were more vulnerable to the Yakutat Bay fishery in 1987 than in most years. Further, the average value from the method was considered too high. These results demonstrated to us that this approach to the Yakutat Bay allocation issue was not going to provide useable results. The analysis is provided for reference in Appendix A1.

The second approach was based upon observations that the Situk origin sockeye salmon stock has a significant proportion of age-2. and –3 fish (2- and 3-freshwater age) and that most other Yakutat area stocks do not utilize these freshwater age/life history patterns. Hence, we proceeded in a fashion similar to that used for the age-0. approach used with the Situk-Ahrnklin Inlet fishery earlier described. The proportions of the sockeye salmon sampled in the Situk River escapements that were age-2. and -3. fish were calculated for the years 1982-2002 and the proportions of the Yakutat Bay harvest that was sampled and determined to be comprised of age-2. and -3. fish were calculated. Then the annual differences in these two data sets were calculated and used for the basis of annual catch allocations. Although in most years, the proportions of age-2. and -3. fish from the Situk escapement exceeded the proportion from the Yakutat Bay harvest samples, the reverse was true in 1990. When the calculations were completed, the estimated proportions of Situk origin sockeye salmon estimated to have been caught in the Yakutat Bay fishery ranged from -10% to 95%, averaging 39%. The negative number was due to 1990 when the proportion of age-2. and -3. fish in the Yakutat Bay fishery exceeded the proportion from the Situk River escapement sample. Another trend was observed; the proportions of fish that were of age-2. and -3. in the Situk River escapement samples seemed to decrease across the time series. This trend in age composition is likely related to trends in the magnitude of the escapements themselves (Figure 2) with the large escapements in the early part of the time series being associated with a higher proportion of age-2. and -3. fish. We elected to abandon this approach. Reasons were threefold. First, 1990 was an obvious problem. Second, the variability in proportions of Situk origin fish across the years ranging from effectively zero to 95% seemed too extreme to be realistic. Third, we are unsure of what other Yakutat Area sockeye salmon stocks may produce some age-2. and -3. fish that may confuse and bias catch allocation estimates derived from this approach. The analysis is provided for reference in Appendix A2.

The third approach was based upon an attempt to reconstruct all the major sockeye salmon runs in the Yakutat area. Although we proceeded with this approach, we had to make a myriad of assumptions to complete the analysis. Most of the escapements for the non-Situk sockeye salmon runs in the Yakutat area are surveyed and peak escapements from the survey program were expanded based upon various assumed expansion factors. In some cases, assumptions had to be made concerning subsistence catches. In some cases such as the effort to reconstruct the Ahrnklin sockeye salmon runs, escapements were estimated based upon expansions of the harvest data. Through this effort we

estimated that the total Yakutat area inshore run of sockeye salmon in 1987 was 455,513 fish. The inshore run of Situk origin sockeye salmon in 1987 was estimated to be 121,175 fish and therefore, the Situk origin run represented 26.6% of the estimated total. The direct sampling based observation in 1987 indicated the portion of the Yakutat Bay harvest comprised of Situk origin sockeye salmon was estimated to have been 50.1%. Consequently, if our total Yakutat area run reconstruction was correct, the Yakutat Bay fishery was positively selective for Situk origin sockeye salmon in 1987 and the selectivity factor was 1.883 (50.1/26.6). We used this value as a constant and applied it to the proportions of Situk origin versus total Yakutat area run reconstructions for the years 1976-2002. Results of this effort provided estimates of the proportions of Situk origin sockeye salmon in the Yakutat Bay fishery for the years 1976-2002 that ranged from 32.7% to 87.6%, averaging 57.5%. While we think these are reasonable estimates given what we know of the fishery, we believe there is great uncertainty in our ability to accurately estimate the total runs of sockeye salmon to the Yakutat area. After giving this considerable thought, we decided to abandon this approach as well. The analysis is provided for reference in Appendix A3.

Instead, we decided to use a simpler approach. Specifically, we decided to develop three models. Each model would assume an alternate assumed proportion of Situk origin sockeye salmon in the Yakutat Bay fishery; 25%, 50% or 75%. From the information we have, these assumptions likely encompass the actual contribution of Situk origin sockeye salmon to the Yakutat Bay fishery. Thus we have alternately allocated 25%, 50%, or 75% of the total annual Yakutat Bay harvests of sockeye salmon and added them to the annual estimates of inshore runs in the years 1976-1986 and 1988-2002. In all three cases we have used the observed value of 50.1% based upon a sampling program or a harvest of 12,769 Situk origin sockeye salmon in the Yakutat Bay fishery in the year 1987 (Table 8).

It may be that some Situk origin sockeye salmon are caught in other mixed stock fisheries. However, we have no information confirming such possible interceptions. And therefore, the three alternate databases discussed above represent our best estimates of the total annual runs of Situk origin sockeye salmon from 1976-2002 (Table 9).

We have no scientific way of estimating precision associated with these Yakutat Bay allocations of Situk River origin sockeye salmon. We are certain that substantial portions of the annual Yakutat Bay harvests of sockeye salmon are Situk origin fish. We just have no scientifically based method that we are willing to rely upon with which to make the annual allocation calculations. On the positive side, the total harvests of sockeye salmon in the Yakutat Bay fishery are relatively small in comparison to the estimates of the inshore runs of Situk origin sockeye salmon (Figure 6). Hence, errors in these Yakutat Bay harvest allocations have but a small affect on the total run estimates. There is already a moderate level of imprecision associated with the inshore run estimates (CV average = 7%, Table 7). Our not including estimates of the uncertainty associated with the Yakutat Bay allocations has a small but additional affect on our estimates of uncertainty regarding inshore run strength across the years. The differences in the annual estimates of Situk origin total runs from 1996-2002 under the conservative assumption of 25% versus the liberal assumption of 75% range as high as 21,023 fish and average 9,184 fish (Table 9). Dividing these annual differences by the mid-point estimates under the assumption of 50% demonstrates that the real effect of this uncertainty is reasonably small (Table 9). We believe the net effect of this uncertainty is the addition of perhaps an average of less than 5% to the coefficients of variation as provided in Table 7. By fully considering three alternate allocations which we are confident encapsulate the possible range, any effect these allocations will have on estimates of the escapement predicted to provide for maximum sustained yield fisheries will be taken into account.

Table 8.-Harvest of sockeye salmon in the Yakutat Bay fishery and three alternate estimates of the number of those fish that were of Situk River origin based upon three alternate assumptions.

Year	Yakutat Bay Commercial Harvests	Yakutat Bay Subsistence Harvests	Yakutat Bay Total Harvests	Assume Situk Origin is 25%	Assume Situk Origin is 50%	Assume Situk Origin is 75%
1976	10,021	200	10,221	2,555	5,111	7,666
1977	14,201	200	14,401	3,600	7,201	10,801
1978	5,399	200	5,599	1,400	2,800	4,199
1979	3,508	200	3,708	927	1,854	2,781
1980	9,454	200	9,654	2,414	4,827	7,241
1981	14,411	200	14,611	3,653	7,306	10,958
1982	24,790	200	24,990	6,248	12,495	18,743
1983	17,893	200	18,093	4,523	9,047	13,570
1984	9,213	200	9,413	2,353	4,707	7,060
1985	11,665	200	11,865	2,966	5,933	8,899
1986	21,956	200	22,156	5,539	11,078	16,617
1987	25,287	200	25,487	12,769	12,769	12,769
1988	14,210	200	14,410	3,603	7,205	10,808
1989	24,524	371	24,895	6,224	12,448	18,671
1990	41,854	192	42,046	10,512	21,023	31,535
1991	28,581	60	28,641	7,160	14,321	21,481
1992	31,616	234	31,850	7,963	15,925	23,888
1993	19,176	166	19,342	4,836	9,671	14,507
1994	14,524	202	14,726	3,682	7,363	11,045
1995	17,312	222	17,534	4,384	8,767	13,151
1996	17,039	103	17,142	4,286	8,571	12,857
1997	17,574	115	17,689	4,422	8,845	13,267
1998	6,782	15	6,797	1,699	3,399	5,098
1999	41,739	78	41,817	10,454	20,909	31,363
2000	24,757	355	25,112	6,278	12,556	18,834
2001	31,047	135	31,182	7,796	15,591	23,387
2002	17,899	150	18,049	4,512	9,025	13,537
Avg.	19,127	185	19,312	5,065	9,657	14,249
Min.	3,508	15	3,708	927	1,854	2,781
Max.	41,854	371	42,046	12,769	21,023	31,535

[a] The subsistence catch was directly monitored from 1989-present. The five-year average of about 200 from the years 1988-1992 is used for the early years in the series, specifically for the years 1976-1988. The 2002 estimate is not yet available; the five-year average of about 150 from 1997-2001 is used for 2002.

Table 9.-Estimated total returns of Situk River origin sockeye salmon under three alternate Yakutat Bay catch allocation assumptions, 1976-2002.

Year	Model 1: 25% Assumption	Model 2: 50% Assumption	Model 3: 75% Assumption	Difference Between Model 1 and Model 3	Difference Divided by Model 2
1976	167,964	170,519	173,075	5,111	3%
1977	286,742	290,343	293,943	7,201	2%
1978	174,125	175,525	176,925	2,800	2%
1979	166,825	167,752	168,679	1,854	1%
1980	124,778	127,191	129,605	4,827	4%
1981	89,234	92,887	96,540	7,306	8%
1982	109,497	115,744	121,992	12,495	11%
1983	82,506	87,029	91,552	9,047	10%
1984	67,599	69,953	72,306	4,707	7%
1985	125,119	128,086	131,052	5,933	5%
1986	83,324	88,863	94,402	11,078	12%
1987	133,944	133,944	133,944	0	0%
1988	91,816	95,418	99,021	7,205	8%
1989	157,340	163,563	169,787	12,448	8%
1990	150,294	160,805	171,317	21,023	13%
1991	186,997	194,157	201,317	14,321	7%
1992	164,839	172,801	180,764	15,925	9%
1993	140,154	144,989	149,825	9,671	7%
1994	151,432	155,113	158,795	7,363	5%
1995	107,471	111,855	116,238	8,767	8%
1996	163,019	167,305	171,590	8,571	5%
1997	87,317	91,739	96,161	8,845	10%
1998	90,387	92,087	93,786	3,399	4%
1999	128,191	138,646	149,100	20,909	15%
2000	81,675	87,953	94,231	12,556	14%
2001	117,754	125,550	133,345	15,591	12%
2002	145,756	150,269	154,781	9,025	6%
Avg.	132,448	137,040	141,632	9,184	7%
Min.	67,599	69,953	72,306	0	0%
Max.	286,742	290,343	293,943	21,023	15%

TOTAL RETURNS AND ESTIMATES OF RECRUITS

AGE COMPOSITION OF SOCKEYE SALMON

The spawning escapement of sockeye salmon in the Situk River has been sampled for age, sex, and length composition on an annual basis since 1982. Similarly, the harvest of sockeye salmon in the Situk-Ahrnklin Inlet fishery has been sampled since 1982. The typical approach to estimating age specific total returns for a harvested stock would be to allocate the estimated annual spawning escapements based on samples from those escapements and add to that the harvests allocated by harvest specific age sampling data. Such an approach is not appropriate for this analysis. The reason is that a significant portion of the total run reconstruction was based upon an allocation of sockeye salmon caught in the Inlet fishery that was driven by differences in the composition of age-0. fish in the Situk escapement and the Inlet mixed stock fishery.

The total age at return composition of the age-0. sockeye salmon sampled from the Inlet fishery is very different from the total age at return composition of either the overall harvest samples or the overall escapement samples (Figure 7). If these differences did not exist, the traditional approach could be used. The age-0. fish sampled from the Inlet fishery tended to be primarily four-year olds (age-0.3) and we believe most are Ahrnklin origin. We have no direct age composition samples from the Ahrnklin escapement. And, the allocation algorithm used assigns 1.59 of the age-0. difference to the Ahrnklin stock in years other than 1987 and 2001. Thus, the approach used assumes most, but not all age-0. fish are Ahrnklin stock along with a portion of the other age classes. We have no scientific way of adjusting the annual harvest age composition samples such that they just represent Situk origin sockeye salmon. The escapement samples, on the other hand, are comprised of 100% Situk origin sockeye salmon.

The primary reason that the traditional approach is typically used is due to selectivity of gear used to harvest salmon. By using gear specific sampling information, any potential bias associated with gear selectivity is taken into account. Because the Situk-Ahrnklin Inlet fishery is prosecuted with gillnets, there is undoubtedly some level of selectivity based upon size and, therefore, age. And, such selectivity could cause some bias in our age specific total run estimates if we rely completely upon escapement age compositions.

Thus we are left with a conundrum. On the one hand we could use the escapement age sampling data only and risk bias introduced into the analysis due to gill net selectivity. Or, we could use available age sampling information from both the escapement and harvest and risk bias introduced into the analysis due to our Inlet allocation approach. Clearly, the age at return of the age-0. is substantially different (Figure 7) and the latter approach will likely introduce significant bias. Hence, the alternate question of whether the Situk gillnet fishery exhibits significant selectivity was considered. An examination of the overall harvest and escapement age samples from 1982-2002 revealed that average age compositions were as follows(%):

Sample	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Total
Harvest	0.0	2.0	30.9	52.8	14.1	0.2	100.0
Escapement	0.0	1.2	28.7	55.9	14.0	0.2	100.0
Difference	-	-0.8	-2.2	3.1	-0.1	-	-

These data indicate to us that although selectivity due to the use of gillnets undoubtedly occurs, the potential bias introduced into our analysis will likely be less than were we to choose the alternative. Given the two alternatives, we believe we can achieve more accuracy and less bias if we simply apply the escapement age composition estimates to the estimated total runs and ignore the potential effects

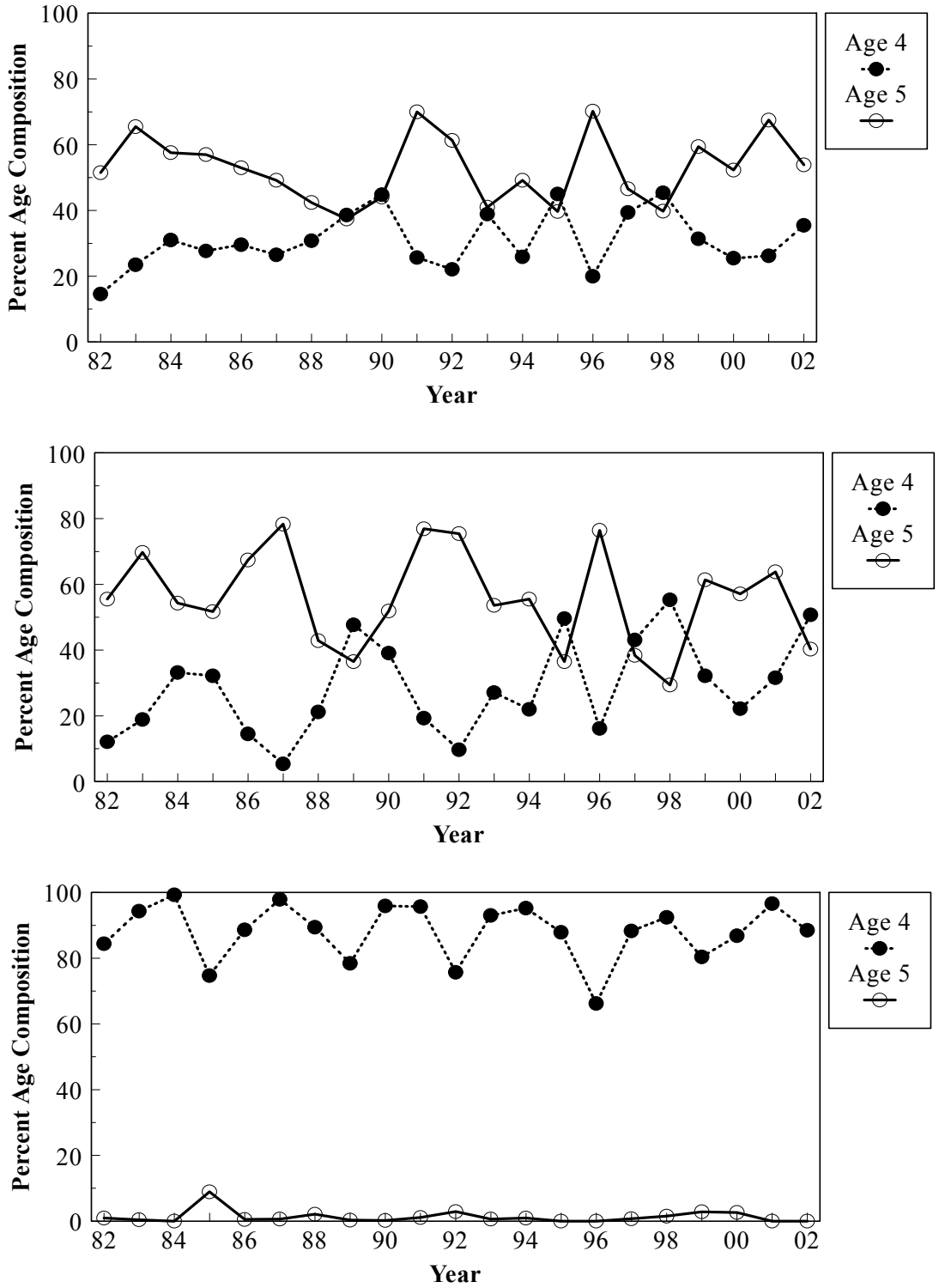

Figure 7.-Age compositions (percent of total age-4 and total age-5) for sockeye salmon sampled from the Situk Lagoon fishery (upper), the Situk River escapement (middle), and for just the age-0. fish sampled from the Situk Lagoon fishery (lower), 1982-2002.

from gillnet selectivity. The effect of this decision will be to introduce some bias into our age specific estimates of total returns.

During the years 1982-2002, an average of 893 sockeye salmon per year were sampled and successfully aged from the Situk River escapement (Table 10). The lowest annual sample size in the 21-year data series was 449 fish in 2001. As a result of relatively large sample sizes, the age composition estimates are relatively precise. Sampling did not occur in the years 1976-1981; average values for the sampled years are used as proxy age composition estimates for those years, though most of these estimates were not required to construct brood tables.

AGE SPECIFIC TOTAL RETURNS AND ESTIMATES OF RECRUITS

The annual age composition estimates as provided in Table 10 were multiplied by the three alternate sets of annual estimates of total returns to provide three alternate sets of age specific total return estimates. Results of these calculations are provided in Appendices A3-A6. Standard errors for age specific total returns were not calculated because: (1) sampling errors associated with the Yakutat Bay catch allocations are unknown; and, (2) the annual age composition estimates are likely biased estimates to an unknown degree when applied to the total return estimates.

The number of Situk River origin sockeye salmon recruits resulting from individual brood year *i* escapements in the data set was estimated as the summation of estimated total returns of age-2 fish in year *i +2,* age-3 fish in year *i+3*, age-4 fish in year *i+4*, age 5 fish in year *i+5*, age-6 fish in year *i+6,* and age-7 fish in year *i+7*. The data used for this summation process is that provided in Appendices A4-A6 and the results of the summations are provided in Table 11. Brood years 1976-1997 (n = 22) were included. An estimate of the age-7 recruits for brood year 1996 will not be available until 2003; the analysis assumed this age cohort will produce 0.02% of the total. Similarly, an estimate of the age-6 recruits for brood year 1997 will not be available until 2003; the analysis assumed this age cohort will produce 14.0% of the total. And, an estimate of the age-7 recruits for brood year 1997 will not be available until 2004; the analysis assumed this age cohort will produce 0.02% of the total. Few Situk River origin sockeye salmon return at age-6 and age-7. These assumptions and estimation procedures were employed to include brood years 1996 and 1997 in the stock-recruit analyses. The assumptions needed and used to include these brood years in the analysis introduces but little uncertainty in recruit estimates for these two brood years.

These calculations laid the basis for developing three alternate paired data sets, each with a sample size of 22 consisting of: (1) estimated escapements during the years 1976-1997 and, (2) estimated total recruitments resulting from these escapements. These paired data sets were used to model the Situk River origin sockeye salmon stock-recruit relationship and develop the best available scientific information upon which a technical analysis of the maximum sustained yield escapement level could be estimated.

SPAWNER-RECRUIT ANALYSIS

Once the three paired data sets were calculated, spawner-recruit relationships were developed by fitting these paired data sets to the following model:

$$R_y = \alpha S_y e^{-\beta S_y} \exp(\varepsilon_y) \qquad (3)$$

where: R_y = estimated total recruitment by brood y;

S_y = spawning escapement that produced brood y;

α = intrinsic rate of population increase in the absence of density-dependent limitations;

β = density-dependent parameter; and

ε_y = process error with mean 0 and variance σ_ε^2.

Table 10.-Percent age composition (in total age) estimates of the annual Situk River sockeye salmon runs, 1976-2002 based upon sampling conducted at the Situk River weir in the years 1982-2002.

Year	Age 2	SE	Age 3	SE	Age 4	SE	Age 5	SE	Age 6	SE	Age 7	SE	Total Samples
1976 [a]	-		**1.2**		**28.7**		**55.9**		**14.0**		**0.2**		0
1977 [a]	-		**1.2**		**28.7**		**55.9**		**14.0**		**0.2**		0
1978 [a]	-		**1.2**		**28.7**		**55.9**		**14.0**		**0.2**		0
1979 [a]	-		1.2		**28.7**		**55.9**		**14.0**		**0.2**		0
1980 [a]	-		1.2		28.7		**55.9**		**14.0**		**0.2**		0
1981 [a]	-		1.2		28.7		55.9		**14.0**		**0.2**		0
1982	-	-	-	-	12.1	1.0	55.5	1.5	32.2	1.4	**0.2**	**0.1**	1,089
1983	0.1	0.1	1.7	0.3	18.9	1.0	69.7	1.2	9.5	0.8	-	-	1,496
1984	-	-	0.2	0.1	33.2	1.3	54.3	1.4	12.1	0.9	0.2	0.1	1,286
1985	-	-	0.1	0.1	32.2	1.5	51.7	1.6	15.2	1.1	0.8	0.3	999
1986	-	-	-	-	14.5	1.1	67.4	1.5	18.1	1.2	-	-	1,016
1987	-	-	-	-	5.4	0.7	78.3	1.3	16.2	1.2	0.1	0.1	940
1988	-	-	1.6	0.4	21.2	1.4	42.9	1.7	33.3	1.6	0.9	0.3	855
1989	-	-	3.3	0.6	47.7	1.7	36.5	1.7	11.9	1.1	0.6	0.3	830
1990	-	-	0.5	0.2	39.1	1.3	51.9	1.3	8.5	0.7	-	-	1,465
1991	-	-	0.1	0.1	19.3	1.3	76.9	1.4	3.6	0.6	0.1	0.1	912
1992	-	-	0.2	0.1	9.7	0.9	75.4	1.3	14.7	1.0	-	-	1,160
1993	-	-	0.8	0.2	27.1	1.2	53.6	1.3	18.1	1.0	0.4	0.2	1,443
1994	-	-	0.5	0.2	22.0	1.2	55.5	1.4	21.7	1.2	0.2	0.1	1,274
1995	-	-	1.0	0.4	49.6	2.2	36.5	2.2	12.9	1.5	-	-	496
1996	-	-	2.4	0.7	16.2	1.7	76.4	1.9	5.0	1.0	-	-	495
1997	0.2	0.2	4.2	0.9	43.1	2.2	38.4	2.2	14.1	1.6	-	-	490
1998	-	-	4.3	0.9	55.3	2.1	29.4	2.0	11.0	1.4	-	-	537
1999	-	-	1.8	0.6	32.2	2.1	61.4	2.2	4.6	0.9	-	-	505
2000	-	-	1.4	0.5	22.2	1.9	57.1	2.3	19.3	1.8	-	-	482
2001	-	-	0.2	0.2	31.6	2.2	63.8	2.3	4.2	1.0	0.2	0.2	449
2002	-	-	1.3	0.5	50.7	2.2	40.3	2.1	7.6	1.1	-	-	538
Avg.	0.0		1.2		28.7		55.9		14.0		0.2		893

[a] Age composition sampling of the Situk River sockeye salmon escapements did not occur in the years 1976-1981. Average values for the years 1982-2002 are used as values of the annual age compositions in the years 1976-1981. Age composition estimates in bold were not used in developing brood tables; the majority of those based on averaging methodology.

Table 11.-Situk River origin sockeye salmon estimated escapements and estimated recruits resulting from those escapements under three alternate assumptions concerning the portion of sockeye salmon harvested in the Yakutat Bay fishery that were of Situk River origin, brood years 1976-1997.

Brood Year	Estimated Escapement	Estimated Recruits with 25% Assumption	Estimated Recruits with 50% Assumption	Estimated Recruits with 75% Assumption
1976	116,989	123,016	127,775	132,533
1977	216,631	95,880	100,859	105,838
1978	146,884	81,086	85,351	89,615
1979	128,879	71,336	73,920	76,504
1980	95,424	103,738	107,133	110,529
1981	61,774	119,240	123,974	128,708
1982	75,501	148,609	150,652	152,694
1983	63,645	65,445	67,734	70,022
1984	58,188	89,802	93,734	97,666
1985	107,586	161,409	170,156	178,904
1986	71,543	232,518	243,529	254,541
1987	72,720	186,852	195,173	203,495
1988	46,160	124,125	128,292	132,459
1989	83,676	136,161	140,093	144,026
1990	69,372	81,825	84,489	87,152
1991	77,922	190,996	197,088	203,180
1992	76,015	70,956	73,579	76,202
1993	59,282	74,017	77,006	79,995
1994	70,984	148,360	157,132	165,903
1995	40,911	96,921	104,281	111,642
1996	63,285	106,888 [a]	113,801 [a]	120,714 [a]
1997	38,182	113,221 [b]	118,316 [b]	123,411 [b]

[a] An estimate of the age-7 recruits for brood year 1996 is not yet available. The analysis assumes this age cohort will produce 0.02% of the total.

[b] An estimate of the age-6 recruits for brood year 1997 is not yet available; the analysis assumes this age cohort will produce 14.0% of the total. An estimate of the age-7 recruits for brood year 1997 is not yet available; the analysis assumes this age cohort will produce 0.02% of the total.

This model, commonly referred to as a Ricker recruitment curve (Ricker 1975), has two parameters, α and β, to estimate, given a series of spawner and resultant recruitment observations or estimates. We assumed the errors were log-normal (as is common for salmon returns), resulting in the log-transformed linear equation:

$$\ln(R_y / S_y) = \ln(\alpha) - \beta S_y + \varepsilon_y \tag{4}$$

Linear regression procedures provided estimates of the intercept ($\ln \alpha$) and the slope (β) in equation 4. Hilborn and Walters (1992:271-2) published the following empirical approximation of the estimated spawning size that produces maximum sustained yield or MSY (S_{MSY}) as a function of estimated parameters:

$$\hat{S}_{MSY} \cong \frac{\hat{\ln \alpha} + \hat{\sigma}_\varepsilon^2 / 2}{\hat{\beta}} [0.5 - 0.07(\hat{\ln \alpha} + \hat{\sigma}_\varepsilon^2 / 2)] \tag{5}$$

where: $\hat{\sigma}_\varepsilon^2$ = the mean square error from the regression.

Stock-recruit analyses with the three alternate databases provided estimates of the escapement level that is predicted to provide for maximum sustained yield fisheries that ranged from 50,632 to 53,003 sockeye salmon (Table 12). The three databases provided alternate estimates for the set of various statistics associated with the three stock-recruit relationships (Table 12), however the three alternate sets of statistical estimates are not substantially different. We suggest that the stock-recruit model based upon the 50% assumption of the interception of Situk origin sockeye salmon in the Yakutat Bay fishery be considered as the best available information at this time. A plot of that relationship is provided in Figure 8. Residuals in the relationship appear to be random with no discernable pattern (Figure 9). Testing for auto-correlation and partial auto-correlation showed that the residuals in the relationship were not auto-correlated.

Total annual escapements of Situk River origin sockeye salmon were enumerated with the aid of a weir in the years 1975-2002 and sport fishery removals upstream of the weir were subtracted from weir counts to estimate annual spawning escapement numbers. Coefficients of variation for the 27 annual escapement estimates were 3% or less except for 1980 (12%) and 1996 (7%). Brood year escapements used in the stock-recruit analysis (1975-1997) ranged from 38,182 to 216,631 and thus contrast in escapements associated with the stock-recruit analysis was about 5.7-fold (Table 2). The measured escapements used in the analysis provided a meaningful level of variation or contrast in annual spawning abundance. According to the Chinook Technical Committee (CTC) of the Pacific Salmon Commission (CTC 1999), the following guidelines concerning contrast in spawning abundance can be used in statistical stock-recruit analyses:

> *"When estimates of spawning abundance are similar – the range is less than 4 times the smallest spawning abundance – statistical stock-recruit analysis is likely to produce a poor estimate of S_{MSY}.*
>
> *When range in spawning abundance is 4 to 8 times the smallest level, statistical stock-recruit analysis should produce better estimates of S_{MSY}, so long as measurement error is not extreme and some of the production-to-spawner ratios are below one at higher levels of spawning abundance.*
>
> *When range is more than 8, statistical analysis should produce the best estimates, so long as some of the production-to-spawner ratios are below one at higher levels of spawning abundance."*

Table 12.-Statistics from stock-recruit relationships calculated for Situk River origin sockeye salmon under three alternate assumptions concerning Situk origin fish harvested in the Yakutat Bay fishery.

Statistic from Stock-Recruit Relationship	Estimated Recruits with 25% Assumption	Estimated Recruits with 50% Assumption	Estimated Recruits with 75% Assumption
Escapement versus Natural Log of (Recruit/Spawner) Relationships:			
No. of observations	22	22	22
R-squared	61.8%	61.6%	61.2%
Regression significance	1.42 E-05	1.54 E-05	1.68 E-05
Mean square errors – regression	4.06	4.06	4.06
Mean square errors –residuals	0.13	0.13	0.13
Intercept (estimate)	1.29	1.33	1.37
S. E. of intercept	0.18	0.18	0.18
P value of intercept	4.67 E-07	3.15 E-07	2.25 E-07
Slope (estimate)	-1.09 E-05	-1.09 E-05	-1.09 E-05
S. E. of slope	0.19 E-05	0.19 E-05	0.19 E-05
P value of slope	1.42 E-05	1.54 E-05	1.68 E-05
Ricker Stock-Recruit Values:			
Ricker α (unadjusted)	3.64	3.79	3.94
Ricker α (adjusted by MS-residuals)	3.88	4.04	4.21
Ricker β	-1.09 E-05	-1.09 E-05	-1.09 E-05
Replacement value approximate)[a]	124,000	128,000	132,000
Predicted Escapement at MSY Related Values Using Stock-Recruit Relationship with Adjusted Ricker α Value:			
Estimated escapement at MSY	50,632	51,854	53,003
Estimated MSY	62,422	67,297	72,219
Exploitation at MSY escapement	55.2%	56.5%	57.7%
90% of estimated MSY	56,180	60,567	64,997
Escapement at 90% of MSY (lower) [a]	33,000	34,000	35,000
Escapement at 90% of MSY (upper) [a]	70,000	72,000	73,000

[a] Rounded to the nearest 1,000 fish.

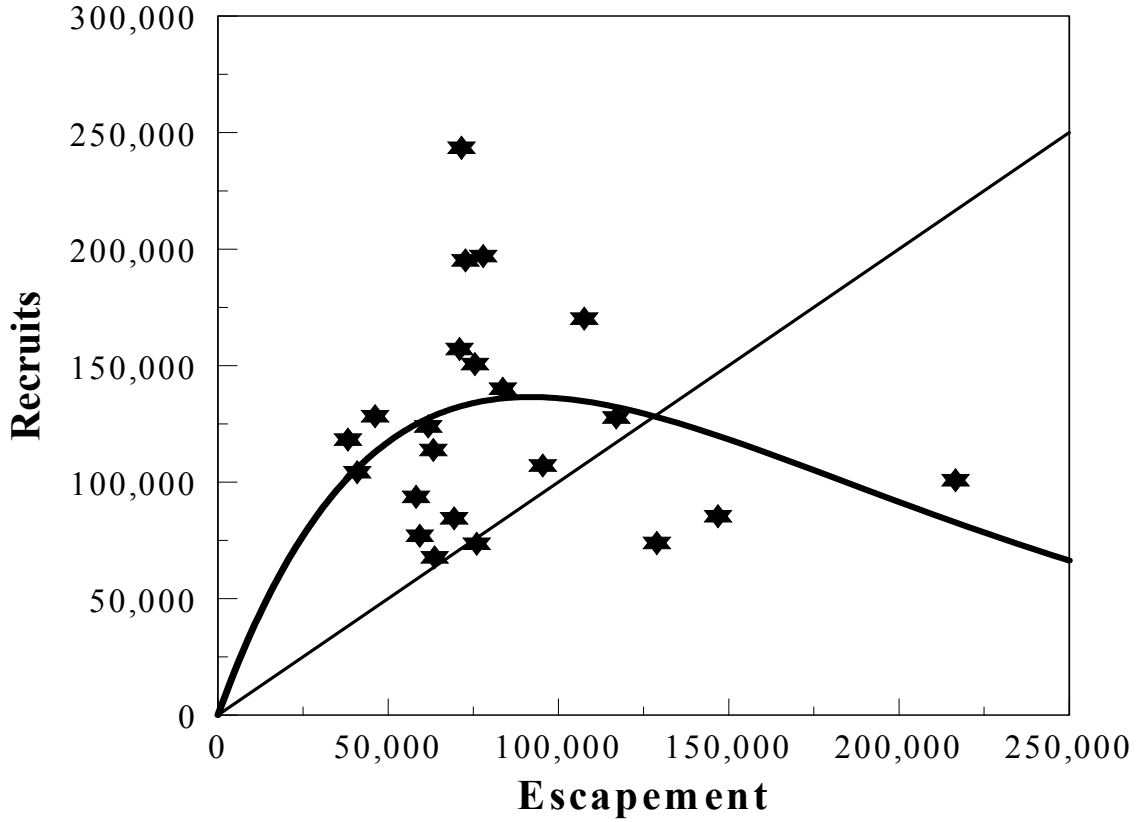

Figure 8.-Stock-recruit relationship for Situk River origin sockeye salmon with the assumption that 50% of the Yakutat Bay harvest of sockeye salmon are fish of Situk River origin.

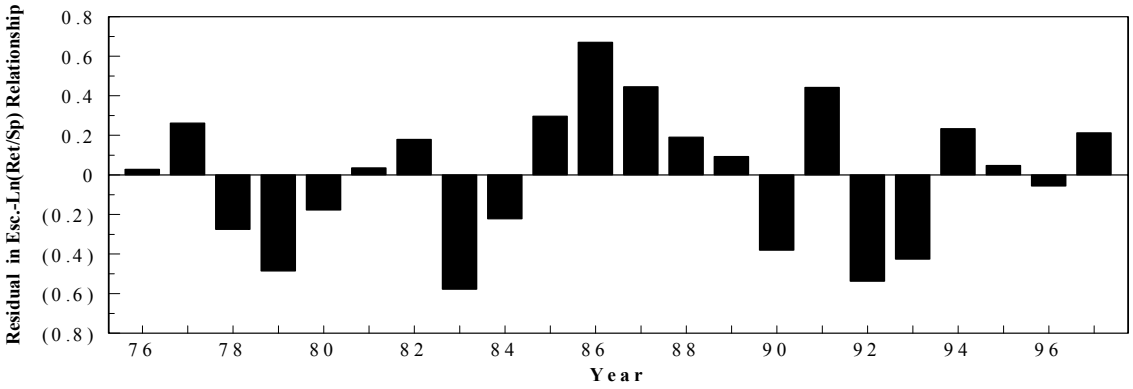

Figure 9.-Residuals in the stock-recruit relationship for Situk River origin sockeye salmon with the assumption that 50% of the Yakutat Bay harvest of sockeye salmon are fish of Situk River origin.

With a contrast of spawning escapements of about 5.7-fold, the Situk River origin sockeye salmon analysis fits into the second category identified by the CTC (1999) general methods. And, therefore production-to-spawner levels are important in determining if data will be adequate to conduct a statistical analysis. Brood years 1977, 1978, and 1979 had the three largest escapements of the 22 brood years used in the stock-recruit analysis and all three of these brood years failed to replace themselves (Figure 8). Measurement error associated with the data utilized in the stock-recruit analysis has been documented, where possible, and certainly could not be considered extreme. As a result, the criterion associated with the second category is fully met for the Situk River origin sockeye salmon analysis. And, thus there are good technical reasons to believe that the Situk River origin sockeye salmon stock-recruit analysis leads to fully useable estimates of the escapement level that produces maximum sustained yield.

The earlier analysis (Clark, McPherson, and Burkholder 1995) estimated that maximum sustained yield fisheries would be provided with an escapement level of about 50,000 sockeye salmon. A fishery management range was adopted and was selected based upon the escapement level that was predicted to provide for 90% or more of the maximum sustained yield. Our current analysis provides essentially the same results. The maximum sustained yield (MSY) escapement value we have identified is about 52,000 sockeye salmon (Table 12). The escapement range predicted to provide for 90% or more of MSY using our 50% Yakutat Bay allocation scheme is 34,000 to 72,000 sockeye salmon. The estimates currently derived are not different enough from the earlier estimates to support a change in the current fishery management regime.

However, the conversion from the point estimate of MSY escapement into a management range based upon the methodology of Eggers (1993) is worth consideration. The Eggers (1993) approach multiplies the point estimate by 0.8 and 1.6 to develop a MSY escapement range. This approach to setting a management range has some favorable features, including: it is practical, it allows for escapements only 20% below the point estimate while allowing more flexibility above the point estimate, and it provides a robust harvest policy. Were that approach utilized, the management range would be 40,000 to 80,000. We anticipate the 90% of MSY derived range (30,000 to 70,000) to more likely maximize harvest potential while the Eggers (1993) approach (40,000 to 80,000) to be a more robust harvest policy.

RECOMMENDATIONS

We believe that preserving long-term stock assessment programs should continue to be one of the highest priorities for the Alaska Department of Fish and Game. These types of programs provide information on the basic biology of the resource that is often poorly understood due to the lack of long-term programs. These programs also provide a continuing time series of data that can be used to understand the causes of abundance fluctuations, allow for comparisons of year-to-year abundance and overall status of the resource, and help improve in-season management. Because of the two to seven year life span of sockeye salmon, many years of data are necessary to monitor the spawning abundance and subsequent returns of a few cohorts, and omission of a single year of data can add considerable uncertainty to an analysis.

We recommend that annual monitoring of sockeye salmon escapements in the Situk River by a weir located downstream near the mouth continue. Age, sex, and size composition sampling of the Situk River escapement of sockeye salmon should also continue, with target sample sizes of approximately 600 fish annually. We recommend that annual commercial, sport, and subsistence fishery harvests of Situk River origin sockeye salmon continue to be monitored to document harvest levels. We recommend that the age, sex, and size composition of sockeye salmon harvested in the Situk-Ahrnklin Inlet and Yakutat Bay commercial set gillnet fisheries continue to be sampled with annual target sample sizes of 600 fish per year.

We recommend that the current stock assessment program be improved through the annual estimation of the escapements of sockeye salmon in the Ahrnklin River. The mark-recapture program conducted by the U. S. Forest Service in 2001 provided a very solid first step in this direction. We recommend that the Alaska Department of Fish and Game work cooperatively with the U. S. Forest Service in 2003 and thereafter to ensure that the annual sockeye salmon escapements in the Ahrnklin River are fully assessed and documented. A series of such annual estimates will provide a much better database than we were able to develop for use in making catch allocations in the Situk fishery. Associated with this is the need to directly document age composition of the Ahrnklin River sockeye salmon escapements. In this report, we have had to speculate that the members of this run are mostly age-0. fish (sub-yearling smolt type). An annual on-the-grounds based age composition sampling program in the Ahrnklin River will greatly improve the information base for future analysts and place them in a position where such speculation is not needed. An associated need is improved estimation of the annual Lost River sockeye salmon escapements. Although this stock is small in magnitude, it too contributes to an unknown degree to harvests of sockeye salmon in the Situk-Ahrnklin Inlet fishery. A series of total sockeye salmon escapement estimates in the Lost River will provide a scientific estimate of the aerial survey expansion factor. In this analysis we had to speculate on the expansion factor. Although we do not believe our speculation concerning this expansion factor significantly affected our results, an on-the-grounds assessment effort will improve future analysis.

The current escapement goal for Situk River sockeye salmon is 30,000 to 70,000 fish through the weir. We recommend that the current escapement goal be retained, although policy makers should give consideration to adopting the Eggers (1993) approach to expressing the management range as 40,000 to 80,000.

We recommend that this escapement goal be reexamined in about five years. A re-analysis of the Situk River origin spawner-recruit relationship will be enhanced after a few more years have passed with additional completed brood years and with improved estimates of the stock composition in the Situk fishery. The majority of the uncertainty associated with annual estimates of Situk River origin sockeye salmon returns in our data sets is due to the Situk fishery catch allocations. We believe that more precise estimates can be developed when additional years of Ahrnklin River (and Lost River) sockeye salmon escapement strengths are available and when the annual age compositions of all three stocks are directly monitored.

ACKNOWLEDGMENTS

The authors thank the many field staff of ADF&G who have persevered through hardships with weather, bears, and people in the collection of the baseline data which formed the foundation for this paper. We thank Iris Frank and Mark Olson, Alaska Department of Fish and Game, Commercial Fisheries Division, Douglas, for providing age composition sampling data. We thank Joanne MacClellan, Alaska Department of Fish and Game, Division of Sport Fish, Anchorage, and Robert Johnson, Alaska Department of Fish and Game, Division of Sport Fish, Yakutat, for providing sport fish harvest information. We thank Kathleen Jensen, Commercial Fisheries Division, Douglas, for providing Klukshu River sockeye salmon data used in the Yakutat Bay catch allocation. We thank Benjamin Van Alen, U.S. Forest Service, Juneau, for providing the 2001 Ahrnklin River mark-recapture data and report. We thank David R. Bernard, Alaska Department of Fish and Game, Sport Fish Division, Anchorage, for conducting the auto-correlation and partial auto-correlation analysis of residuals and for his technical insight into residual interpretation. We thank David R. Bernard, Harold Geiger (ADFG, Commercial Fisheries Division, Douglas), Robert Johnson, Scott M. Kelley (ADFG, Commercial Fisheries Division, Douglas), and Douglas McBride (U.S. Fish and Wildlife Service, Anchorage) for review comments of the manuscript. We thank Joanne MacClellan for final text layout and preparation of this report.

LITERATURE CITED

Chinook Technical Committee (CTC). 1999. Maximum sustained yield of biologically based escapement goals for selected chinook salmon stocks used by the Pacific Salmon Commission's Chinook Technical Committee for escapement assessment, Volume I. Pacific Salmon Commission Joint Chinook Technical Committee Report No. TCCHINOOK (99)-3, Vancouver, British Columbia, Canada.

Clark, J. H., S. A. McPherson, and A. Burkholder. 1995. Biological escapement goal for Situk River sockeye salmon. Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development, Regional Information Report Number 1J95-22. Douglas. 31 pp.

Eggers, D. M. 1993. Robust harvest policies for Pacific salmon fisheries. , p. 85-106 in G. Kruse, D. M. Eggers, R. J. Marasco, C. Pautzke, and T. J. Quinn II editors. Proceedings of the International Symposium on Management Strategies for exploited Fish Populations. Alaska Sea Grant College Program report No. 93-02, University of Alaska Fairbanks.

McPherson, S. A. and J. H. Clark. 1995. Stock composition studies of Situk River sockeye salmon 1987 and 1988. Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development, Regional Information Report Number 1J95-11. Douglas. 58 pp.

Hilborn, R., and C. J. Walters. 1992. Quantitative fisheries stock assessment. Chapman and Hall. New York.

Ricker, W. E. 1975. Computation and Interpretation of Biological Statistics of Fish Populations. Bulletin of the Fisheries Research Board of Canada No. 191. 382 pp.

Schaberg, K. 2002. Sockeye salmon mark recapture survey Ahrnklin River system Yakutat Alaska 2001. Mimeograph report by U.S. Forest Service, Yakutat, Alaska. 5 pp.

APPENDIX A

Appendix A1.-Yakutat Bay sockeye salmon harvest allocations based upon instantaneous fishing effort. The 1987 estimate (in bold) represents direct sampling based estimation of the interception of Situk origin sockeye salmon in the Yakutat Bay fishery.

Year	Situk Inshore Run	Yakutat Bay Fishing Effort (boat-days)	Harvest Rate Adjusted For Fishing Effort	Harvest Rate per Unit Effort	Harvest of Situk Origin Sockeye Yakutat Bay	Yakutat Bay Commercial Harvest	Yakutat Bay Subsistence Harvest	Yakutat Bay Total Harvest	Percent Situk Origin Sockeye In Harvest
1980	121,640	240	0.06481	0.0002701	8,430	9,454	200	9,654	87.3%
1981	85,582	434	0.11721	0.0002701	11,362	14,411	200	14,611	77.8%
1982	103,249	410	0.11072	0.0002701	12,856	24,790	200	24,990	51.4%
1983	77,983	292	0.07886	0.0002701	6,676	17,893	200	18,093	36.9%
1984	65,246	199	0.05374	0.0002701	3,706	9,213	200	9,413	39.4%
1985	122,153	335	0.09047	0.0002701	12,150	11,665	200	11,865	102.4%
1986	77,785	359	0.09695	0.0002701	8,351	21,956	200	22,156	37.7%
1987	121,175	353	0.09533	0.0002701	12,769	25,287	200	25,487	**50.1%**
1988	88,213	586	0.15825	0.0002701	16,585	14,210	200	14,410	115.1%
1989	151,116	775	0.20930	0.0002701	40,000	24,524	371	24,895	160.7%
1990	139,782	1,085	0.29301	0.0002701	57,934	41,854	192	42,046	137.8%
1991	179,819	706	0.19066	0.0002701	42,361	28,581	60	28,641	147.9%
1992	156,876	621	0.16771	0.0002701	31,611	31,616	234	31,850	99.2%
1993	135,318	519	0.14016	0.0002701	22,058	19,176	166	19,342	114.0%
1994	147,750	494	0.13341	0.0002701	22,746	14,524	202	14,726	154.5%
1995	103,088	657	0.17743	0.0002701	22,236	17,312	222	17,534	126.8%
1996	158,421	424	0.11451	0.0002701	20,486	17,039	103	17,142	119.5%
1997	82,894	317	0.08561	0.0002701	7,761	17,574	115	17,689	43.9%
1998	88,688	305	0.08237	0.0002701	7,961	6,782	15	6,797	117.1%
1999	117,737	679	0.18337	0.0002701	26,437	41,739	78	41,817	63.2%
2000	75,397	408	0.11018	0.0002701	9,336	24,757	355	25,112	37.2%
2001	109,959	1,189	0.32110	0.0002701	52,007	31,047	135	31,182	166.8%
2002	141,244	662	0.17878	0.0002701	30,749	17,899	150	18,049	170.4%
Avg.					21,155				98.1%
Min.					3,706				36.9%
Max.					57,934				170.4%

Appendix A2.-Yakutat Bay sockeye salmon harvest allocations based upon proportions of age-2. and -3. fish. The 1987 estimate (in bold) represents direct sampling based estimation of the interception of Situk origin sockeye salmon in the Yakutat Bay fishery.

Year	Situk Escapement Percent age -2 and age-3	SE	Yakutat Bay Escapement Percent age-2 and age–3	SE	Percent Difference	Harvest Based On 1987 Estimate (50.1%)	Yakutat Bay Harvest	Situk Origin Sockeye in Yakutat Harvest	Percent Situk in Yakutat Bay
1982	46.74	1.51	11.68	1.25	35.1	0.91	24,790	22,479	91%
1983	14.17	0.90	5.86	0.58	8.3	0.22	17,893	3,848	22%
1984	18.51	1.08	6.63	0.87	11.9	0.31	9,213	2,829	31%
1985	30.93	1.46	9.54	0.83	21.4	0.55	11,665	6,454	55%
1986	25.79	1.37	11.47	0.76	14.3	0.37	21,956	8,131	37%
1987	22.02	1.35	2.65	0.40	19.4	0.50	25,287	12,769	**50%**
1988	57.89	1.69	21.33	1.02	36.6	0.95	14,210	13,441	95%
1989	29.52	1.58	24.21	1.19	5.3	0.14	24,524	3,366	14%
1990	11.47	0.83	15.16	1.14	-3.7	-0.10	41,854	-3,998	-10%
1991	17.54	1.26	7.95	0.76	9.6	0.25	28,581	7,093	25%
1992	20.52	1.19	11.86	0.93	8.7	0.22	31,616	7,077	22%
1993	43.87	1.31	19.66	1.18	24.2	0.63	19,176	12,005	63%
1994	44.98	1.39	17.14	1.54	27.8	0.72	14,524	10,459	72%
1995	21.80	1.85	15.08	1.27	6.7	0.17	17,312	3,011	17%
1996	22.20	1.87	7.87	1.17	14.3	0.37	17,039	6,318	37%
1997	21.00	1.84	6.19	1.20	14.8	0.38	17,574	6,733	38%
1998	19.00	1.69	8.10	1.62	10.9	0.28	6,782	1,912	28%
1999	20.00	1.78	6.65	1.09	13.3	0.35	41,739	14,409	35%
2000	32.20	2.13	8.78	1.21	23.4	0.61	24,757	15,001	61%
2001	9.10	1.36	5.35	1.00	3.8	0.10	31,047	3,014	10%
2002	14.87	1.54	7.78	1.17	7.1	0.18	17,899	3,283	18%
Avg.								7,602	39%
Min.								-3,998	-10%
Max.								22,479	95%

Appendix A3.-Yakutat Bay sockeye salmon harvest allocations based upon proportions of total Yakutat Area inshore sockeye salmon runs. The 1987 estimate (in bold) represents direct sampling based estimation of the interception of Situk origin sockeye salmon in the Yakutat Bay fishery.

Year	Situk Inshore Run	Yakutat Area Inshore Run	Situk Portion of Total	Situk Vulnerability	Yakutat Bay Sockeye Harvest	Situk Origin Harvest in Yakutat Bay	Percent Situk Origin
1976	165,409	445,767	37.1%	1.8833	10,221	7,143	69.9%
1977	283,142	652,206	43.4%	1.8833	14,401	11,774	81.8%
1978	172,726	516,068	33.5%	1.8833	5,599	3,529	63.0%
1979	165,898	477,621	34.7%	1.8833	3,708	2,426	65.4%
1980	121,640	407,697	29.8%	1.8833	9,654	5,425	56.2%
1981	85,582	389,087	22.0%	1.8833	14,611	6,053	41.4%
1982	103,249	554,349	18.6%	1.8833	24,990	8,766	35.1%
1983	77,983	449,495	17.3%	1.8833	18,093	5,912	32.7%
1984	65,246	299,246	21.8%	1.8833	9,413	3,865	41.1%
1985	122,153	566,083	21.6%	1.8833	11,865	4,822	40.6%
1986	77,785	420,829	18.5%	1.8833	22,156	7,713	34.8%
1987	121,175	455,513	26.6%	1.8833	25,487	12,769	**50.1%**
1988	88,213	305,103	28.9%	1.8833	14,410	7,846	54.5%
1989	151,116	555,404	27.2%	1.8833	24,895	12,757	51.2%
1990	139,782	561,322	24.9%	1.8833	42,046	19,719	46.9%
1991	179,819	468,976	38.3%	1.8833	28,641	20,682	72.2%
1992	156,876	561,447	27.9%	1.8833	31,850	16,760	52.6%
1993	135,318	617,433	21.9%	1.8833	19,342	7,984	41.3%
1994	147,750	445,052	33.2%	1.8833	14,726	9,207	62.5%
1995	103,088	353,320	29.2%	1.8833	17,534	9,635	54.9%
1996	158,421	382,503	41.4%	1.8833	17,142	13,371	78.0%
1997	82,894	269,968	30.7%	1.8833	17,689	10,229	57.8%
1998	88,688	267,440	33.2%	1.8833	6,797	4,245	62.5%
1999	117,737	253,078	46.5%	1.8833	41,817	36,638	87.6%
2000	75,397	230,255	32.7%	1.8833	25,112	15,487	61.7%
2001	109,959	286,462	38.4%	1.8833	31,182	22,542	72.3%
2002	141,244	313,792	45.0%	1.8833	18,049	15,301	84.8%
Avg.						11,207	57.5%
Min.						2,426	32.7%
Max.						36,638	87.6%

Appendix A4.-Estimated age specific (in total age) total returns of Situk River sockeye salmon under the assumption that 25% of the harvest in the Yakutat Bay fishery are fish of Situk River origin, 1976-2002.

Year	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Total
1976	-	2,050	48,256	93,812	23,514	306	167,937
1977	-	3,499	82,381	160,152	40,142	522	286,697
1978	-	2,125	50,026	97,253	24,376	317	174,098
1979	-	2,036	47,929	93,176	23,354	304	166,799
1980	-	1,523	35,849	69,691	17,468	227	124,758
1981	-	1,089	25,637	49,839	12,492	162	89,220
1982	-	-	13,272	60,731	35,292	201	109,497
1983	110	1,434	15,608	57,522	7,831	-	82,506
1984	-	105	22,446	36,691	8,200	158	67,599
1985	-	125	40,329	64,626	19,037	1,002	125,119
1986	-	-	12,056	56,178	15,090	-	83,324
1987	-	-	7,267	104,875	21,659	142	133,944
1988	-	1,503	19,437	39,411	30,605	859	91,816
1989	-	5,118	75,068	57,438	18,767	948	157,340
1990	-	718	58,784	78,071	12,721	-	150,294
1991	-	205	36,087	143,733	6,766	205	186,997
1992	-	284	15,915	124,340	24,300	-	164,839
1993	-	1,166	37,977	75,079	25,350	583	140,154
1994	-	832	33,282	84,036	32,925	357	151,432
1995	-	1,075	53,306	39,227	13,864	-	107,471
1996	-	3,912	26,409	124,547	8,151	-	163,019
1997	175	3,667	37,634	33,530	12,312	-	87,317
1998	-	3,887	49,984	26,574	9,943	-	90,387
1999	-	2,307	41,278	78,710	5,897	-	128,191
2000	-	1,143	18,132	46,637	15,763	-	81,675
2001	-	236	37,210	75,127	4,946	236	117,754
2002	-	1,896	73,962	58,790	11,108	-	145,756

Appendix A5.-Estimated age specific total returns of Situk River sockeye salmon under the assumption that 50% of the harvest in the Yakutat Bay fishery are fish of Situk River origin, 1976-2002.

Year	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Total
1976	-	2,081	48,990	95,239	23,872	310	170,492
1977	-	3,543	83,416	162,163	40,646	529	290,297
1978	-	2,142	50,429	98,035	24,572	320	175,497
1979	-	2,047	48,195	93,693	23,484	305	167,725
1980	-	1,552	36,542	71,039	17,806	232	127,171
1981	-	1,133	26,687	51,880	13,004	169	92,872
1982	-	-	14,030	64,196	37,306	213	115,744
1983	116	1,513	16,463	60,676	8,261	-	87,029
1984	-	109	23,227	37,968	8,486	163	69,953
1985	-	128	41,285	66,158	19,488	1,026	128,086
1986	-	-	12,857	59,912	16,093	-	88,863
1987	-	-	7,267	104,875	21,659	142	133,944
1988	-	1,562	20,200	40,957	31,806	893	95,418
1989	-	5,321	78,037	59,710	19,509	985	163,563
1990	-	768	62,895	83,531	13,611	-	160,805
1991	-	213	37,469	149,237	7,025	213	194,157
1992	-	298	16,684	130,346	25,473	-	172,801
1993	-	1,206	39,287	77,669	26,225	603	144,989
1994	-	852	34,091	86,079	33,726	365	155,113
1995	-	1,119	55,480	40,827	14,429	-	111,855
1996	-	4,015	27,103	127,821	8,365	-	167,305
1997	183	3,853	39,540	35,228	12,935	-	91,739
1998	-	3,960	50,924	27,074	10,130	-	92,087
1999	-	2,496	44,644	85,128	6,378	-	138,646
2000	-	1,231	19,526	50,221	16,975	-	87,953
2001	-	251	39,674	80,101	5,273	251	125,550
2002	-	1,955	76,252	60,610	11,452	-	150,269

Appendix A6.-Estimated age specific total returns of Situk River sockeye salmon under the assumption that 75% of the harvest in the Yakutat Bay fishery are fish of Situk River origin, 1976-2002.

Year	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Total
1976	-	2,112	49,725	96,666	24,229	315	173,047
1977	-	3,587	84,450	164,174	41,150	535	293,896
1978	-	2,159	50,831	98,817	24,768	322	176,897
1979	-	2,058	48,462	94,211	23,614	307	168,652
1980	-	1,582	37,236	72,387	18,144	236	129,584
1981	-	1,178	27,736	53,920	13,515	176	96,524
1982	-	-	14,787	67,661	39,320	224	121,992
1983	122	1,591	17,319	63,830	8,690	-	91,552
1984	-	112	24,008	39,245	8,771	169	72,306
1985	-	131	42,241	67,690	19,940	1,049	131,052
1986	-	-	13,658	63,647	17,096	-	94,402
1987	-	-	7,267	104,875	21,659	142	133,944
1988	-	1,621	20,962	42,504	33,007	927	99,021
1989	-	5,523	81,007	61,983	20,252	1,023	169,787
1990	-	819	67,007	88,991	14,501	-	171,317
1991	-	221	38,851	154,741	7,285	221	201,317
1992	-	312	17,453	136,352	26,647	-	180,764
1993	-	1,246	40,597	80,260	27,099	623	149,825
1994	-	872	34,900	88,122	34,526	374	158,795
1995	-	1,162	57,654	42,427	14,995	-	116,238
1996	-	4,118	27,798	131,095	8,580	-	171,590
1997	192	4,039	41,445	36,926	13,559	-	96,161
1998	-	4,033	51,864	27,573	10,316	-	93,786
1999	-	2,684	48,010	91,547	6,859	-	149,100
2000	-	1,319	20,919	53,806	18,187	-	94,231
2001	-	267	42,137	85,074	5,600	267	133,345
2002	-	2,014	78,541	62,430	11,796	-	154,781